In Partial Fulfillment of Consent Order
Requirements
CERCLA Docket No. 87 - 1.

SOURCE CONTROL FEASIBILITY STUDY

SHERIDAN DISPOSAL SERVICES SITE
WALLER COUNTY, TEXAS

VOLUME II

011061

Prepared for:

The Sheridan Site Committee

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W.O. #91-01

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APPENDIX A

Dike Evaporation System and Background Borings

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APPENDIX A

Dike Evaporation System and Background Borings

Dike Borings

A series of borings were made through the depth of the dike to confirm its construction and to characterize soils and waste materials within it. Figure A-1 shows the location of these borings. Tables A-1 and A-2 summarize the organic and inorganic analytical results. Boring logs are in Attachment A.

Evaporation System Borings

Soil samples were collected from nineteen locations throughout the evaporation system during December 1987 (Figure A-2). Samples from locations EVAP-2 through 19 were collected using a hand auger to a total depth of 1 foot. Location 1 was sampled to a depth of six feet using hollow stem auger techniques. All soils were analyzed for indicator parameters. Sample descriptions for locations EVAP-2 through 19 are found in Table A-3: a boring log for location EVAP-1 is in Attachment B.

Analytical results show no detectable indicator parameters in the volatile and semi-volatile fractions. PCBs (as Aroclor 1248) were detected at locations EVAP-3 and EVAP-15 in concentrations of 120 ug/kg and 110 ug/kg, respectively. Indicator metals were found at low concentrations and in the same range as the background samples. A summary of analytical results is in Table A-4.

Background Borings

In order to determine background concentrations of organics and metals, five background borings were sampled during December 1987 using hollow stem auger techniques. Boring locations are shown in Figure A-3 with boring logs in Attachment A. Each boring was completed to a depth of 10 feet, with soil samples collected approximately every two feet. The shallowest sample for each location was analyzed for the full suite of indicator parameters determined in the Endangerment Assessment and agreed to by EPA [benzene, 2-4 dimethylphenol, ethylbenzene, naphthalene, PCBs (total as Aroclor 1016), phenol, tetrachloroethylene, toluene, trichloroethylene, chromium, lead, nickel and zinc]. Samples from depths greater than 2 feet were analyzed for indicator metals only.

Analytical results show that no indicator parameters were found above detection limits for the volatile, semi-volatile, or PCB fractions. Metals concentrations were low and similar between each boring. Analytical data for metals are summarized in Table A-5.

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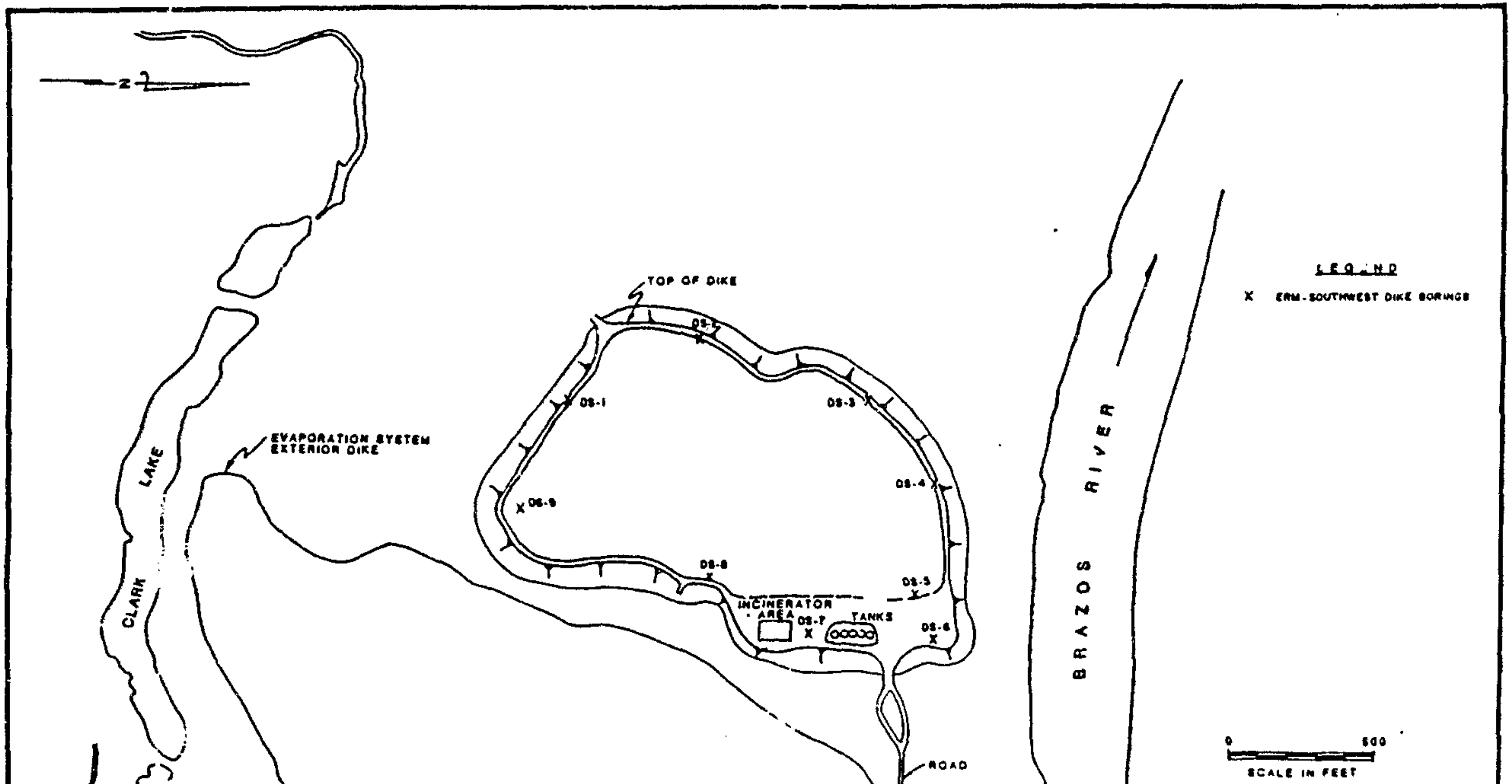

ERM-Southwest, Inc.
HOUSTON, TEXAS

FIGURE A-1
LOCATION MAP FOR DIKE SAMPLES
COLLECTED JULY 6-10, 1987
SHERIDAN DISPOSAL SERVICES
HEMPSTEAD, TEXAS

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TABLE A-1

Summary of Analytical Results for Inorganic Indicators
for Dike Soils Sampled July 6-10 1987

Chemical Name	DS-1 Dike 11	DS-1 Dike 12	DS-1 Dike 1001	DS-1 Dike 2011	DS-1 Dike 2012	DS-1 Dike 2013	DS-1 Dike 2014	DS-1 Dike 2015	DS-2 Dike 21	DS-2 Dike 22	DS-2 Dike 2021	DS-2 Dike 2022	DS-2 Dike 2023	DS-2 Dike 2024	DS-2 Dike 2025
Depth of Sample	0-4'	4-8	8-10'	10-12'	12-14	14-16'	16-18	18-20'	0-3'	4-8'	10-12	12-14	14-16	16-18	18-20
Sample Type	SOIL	SOIL	SLUDGE	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SLUDGE	SOIL	SOIL	SOIL	SOIL	SOIL
Total Organic Carbon (%)	1.51	1.43	19.5	0.9	0.67	0.53	0.5	0.13	0.11	3.15	0.32	0.27	0.38	0.11	ND(<0.02)
pH	8.53	8.25	8.73	8.39	8.35	7.81	7.38	7.56	8.7	6.67	7.6	7.54	8.18	8.5	8.72
METALS (mg/kg)															
Chromium	NT	NT	8	NT	NT	NT	NT	5	NT	7	NT	NT	NT	NT	4
Lead	NT	NT	10	NT	NT	NT	NT	6	NT	10	NT	NT	NT	NT	<5
Nickel	NT	NT	9	NT	NT	NT	NT	8	NT	10	NT	NT	NT	NT	5
Zinc	52	43	2400	33	30	39	26	16	32	38	19	15	13	11	10

Chemical Name	DS-3 Dike 31	DS-3 Dike 32	DS-3 Dike 2031	DS-3 Dike 2032	DS-3 Dike 2033	DS-3 Dike 2034	DS-3 Dike 2035	DS-4 Dike 41	DS-4 Dike 42	DS-4 Dike 2041	DS-4 Dike 2042	DS-4 Dike 2043	DS-4 Dike 2044	DS-4 Dike 2045	DS-4 Dike 1002
Depth of Sample	0-3'	4-8'	10-12'	12-14'	14-16'	16-18'	18-20'	0-4'	4-9'	10-12'	12-14'	14-16'	16-18'	18-20	22-24
Sample Type	SOIL	SLUDGE	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL/SLUDGE	SLUDGE	SOIL	FREE OIL	SOIL	SOIL	SOIL	SOIL
Total Organic Carbon (%)	0.86	16.66	0.3	0.2	0.06	ND(<0.02)	0.8	0.64	3.42	0.43	0.47	0.08	ND(<0.04)	0.06	0.09
pH	6.99	6.45	7.66	8.36	6	8.44	8.23	8.87	7.57	8.36	8.72	8.12	8.84	8.98	8.91
METALS (mg/kg)															
Chromium	NT	19	NT	NT	NT	NT	11	NT	60	NT	NT	8	NT	NT	NT
Lead	NT	19	NT	NT	NT	NT	13	NT	16	NT	NT	10	NT	NT	NT
Nickel	NT	9	NT	NT	NT	NT	16	NT	20	NT	NT	12	NT	NT	NT
Zinc	23	1100	20	12	13	12	33	30	70	41	46	22	11	10	17

Chemical Name	DS-5 Dike 51	DS-5 Dike 52	DS-5 Dike 2051	DS-5 Dike 2052	DS-5 Dike 2053	DS-5 Dike 2054	DS-5 Dike 2055	DS-5 Dike 2056	DS-6 Dike 61	DS-6 Dike 62	DS-6 Dike 2061	DS-6 Dike 2062	DS-6 Dike 2063	DS-6 Dike 2064	DS-6 Dike 2065	DS-6 Dike 1004
Depth of Sample	0-3'	5-10'	10-12	12-14	14-19'	19-21'	21-23'	23-25'	0-3'	3-9'	9-11'	11-13'	13-15	15-17'	17-19	20-24
Sample Type	SOIL	WASTE	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SLUDGE	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Total Organic Carbon (%)	0.88	9.61	1.73	1.75	0.5	0.41	0.04	3.34	0.59	1.02	0.98	0.96	0.49	0.23	0.21	ND(<0.02)
pH	8.85	7.19	8.5	8.58	8.5	7.78	8.32	8.5	7.84	4.81	6.14	7.53	8.16	7.81	8	6.51
METALS (mg/kg)																
Chromium	NT	50	NT	NT	NT	NT	NT	7	NT	13	NT	NT	NT	NT	NT	5
Lead	NT	1200	NT	NT	NT	NT	NT	6	NT	740	NT	NT	NT	NT	NT	6
Nickel	NT	38	NT	NT	NT	NT	NT	9	NT	13	NT	NT	NT	NT	NT	8
Zinc	2900	340	67	60	51	30	25	17	24	84	23	41	40	17	17	15

NOTES
NT = Not tested
ND() = Not Detected (detection limit)

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TABLE A-1 (continued)

Summary of Analytical Results for Inorganic Indicators
for Dike Oils sampled July 6-10, 1987

Chemical Name	DS-7 Dike 71	DS-7 Dike 72	DS-7 Dike 1003	DS-7 Dike 2071	DS-7 Dike 2072	DS-7 Dike 2073	DS-7 Dike 2074
Depth of Sample	0-4'	4-7'	7-9'	9-12'	12-14'	14-16	16-18'
Sample Type	SOIL	SOIL	WASTE	SOIL	SOIL	SOIL	SOIL
Total Organic Carbon (%)	0.53	0.68	6.71	0.33	0.37	1.56	0.08
pH	8.59	8.08	8.32	7.89	7.48	8	7.98
METALS (mg/kg)							
Chromium	NT	NT	7	NT	NT	NT	5
Lead	NT	NT	21	NT	NT	NT	7
Nickel	NT	NT	7	NT	NT	NT	8
Zinc	26	18	670	22	24	17	15

Chemical Name	DS-8 Dike 81	DS-8 Dike 82	DS-8 Dike 2081	DS-8 Dike 2082	DS-8 Dike 2083	DS-8 Dike 2084	DS-8 Dike 2085	DS-8 Dike 2086
Depth of Sample	0-3'	3-8'	8-10'	10-12'	12-14'	14-16'	16-18	18-20
Sample Type	SOIL	SOIL/SLUDG	SLUDGE	SOIL	SOIL/ORG	SOIL	SOIL	SOIL
Total Organic Carbon (%)	0.53	0.08	17.02	0.51	0.31	0.16	ND(<0.04)	ND(<0.04)
pH	8.1	8.29	8.2	7.54	8.1	8.46	8.36	5.39
METALS (mg/kg)								
Chromium	NT	8	14	NT	10	NT	NT	NT
Lead	NT	8	870	NT	9	NT	NT	NT
Nickel	NT	10	9	NT	13	NT	NT	NT
Zinc	38	24	530	15	23	14	20	14

Chemical Name	DS-9 Dike 91	DS-9 Dike 92	DS-9 Dike 2091	DS-9 Dike 2092	DS-9 Dike 2093	DS-9 Dike 2094	DS-9 Dike 2095	DS-9 Dike 2096	DS-9 Dike 2097
Depth of Sample	0-3'	3-9'	9-10'	10-12'	12-14'	14-16'	16-18'	20-22'	22-24'
Sample Type	SOIL	SLUDGE	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Total Organic Carbon (%	0.63	23.3	1.32	0.44	0.17	0.44	0.07	0.13	0.03
pH	8.65	8.81	8.75	7.9	7.9	8.22	8.15	8.09	8.4
METALS (mg/kg)									
Chromium	NT	12	NT	NT	6	NT	NT	NT	NT
Lead	NT	8	NT	NT	[illegible]	NT	NT	NT	NT
Nickel	NT	16	NT	NT	7	NT	NT	NT	NT
Zinc	42	1000	40	17	15	31	17	21	20

NOTES
NT = Not tested
ND() = Not Detected (detection limit)

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TABLE A-2

Summary of TCL Analyses for Organic Compounds (in mg/kg) Detected in

Dike Soils Sampled Oct. 6-10, 1987

Chemical Name	64035-015 DS-1 Dike 1001	64035-009 DS-2 Dike 22	64035-029 DS-3 Dike 32	64035-016 DS-4 Dike 42	64035-039 DS-4 Dike 2043	64035-055 DS-5 Dike 52	64035-062 DS-5 Dike 2055	64035-047 DS-6 Dike 62
Depth of Sample	6-10'	3-9'	4-8'	4 9	14-16'	5-10'	23-25'	3-9'
Sample Description	Sludge	Sludge	Sludge	Sludge	Soil	Waste	Soil	Sludge
VOLATILE ORGANIC FRACTION								
Benzene	0 1	1 3	6	ND(<0 4)	0 013	210	ND(<0 005)	1 7
Chlorobenzene	ND(<0 045)	ND(<0 5)	4 1	0 49	0 39	ND(<17)	ND(<0 005)	ND(<0 6)
Ethylbenzene	ND(<0 045)	2 8	ND(<2 9)	1 4	0 022	100	ND(<0 005)	1 1
Styrene	ND(<0 045)	2 8	ND(<2 9)	0 55	ND(<0 005)	ND(<17)	ND(<0 005)	ND(<0 6)
Toluene	0 094	0 95	ND(<2 9)	8 9	0 016	180	ND(<0 005)	1 5
Xylene	0 088	16	ND(<2 9)	5 7	0 11	510	ND(<0 005)	5 6
Acetone	1 4	5 6	ND(<14)	6 6	0 89	ND(<85)	0 19	19
Carbon disulfide	ND(<0 045)	ND(<0 5)	19	ND(<0 4)	ND(<0 005)	ND(<17)	ND(<0 005)	ND(<0 6)
Methylene chloride	5 6	27	ND(<14)	ND(<2)	0 44	ND(<85)	ND(<0 025)	ND(<3)
1 1-dichloroethene	ND(<0 045)	0 57	ND(<2 9)	ND(<0 4)	ND(<0 005)	ND(<17)	ND(<0 005)	ND(<0 6)
1 2-dichloroethane	ND(<0 045)	ND(<0 5)	ND(<2 9)	ND(<0 4)	ND(<0 005)	44	ND(<0 005)	ND(<0 6)
2-Butanone (MEK)	0 54	ND(<2 5)	ND(<14)	ND(<2)	0 01	ND(<85)	0 17	9 0
2-Hexanone	0 32	ND(<1 0)	ND(<5 8)	ND(<0 8)	ND(<0 01)	ND(<34)	ND(<0 01)	1 2
4-methyl-2-pentanone (MIBK)	1 5	1 2	ND(<5 8)	3 9	0 05	77	0 049	3 4
SEMIVOLATILE ORGANIC FRACTION								
Acenapthene	ND(<33)	ND(<3 3)	ND(<13)	170	5 5	ND(<26)	ND(<0 66)	ND(<6 6)
Chrysene	ND(<33)	ND(<3 3)	ND(<13)	ND(<16)	ND(<1 6)	ND(<26)	ND(<0 66)	ND(<6 6)
Fluorene	ND(<33)	ND(<3 3)	ND(<13)	47	1 9	ND(<26)	ND(<0 66)	ND(<6 6)
2-Methylnaphthalene	ND(<33)	ND(<3 3)	ND(<13)	660	20	81	ND(<0 66)	ND(<6 6)
Naphthalene	ND(<33)	ND(<3 3)	ND(<13)	ND(<16)	ND(<1 6)	47	ND(<0 66)	ND(<6 6)
Bis-(2-ethylhexyl) phthalate	ND(<33)	ND(<3 3)	ND(<13)	ND(<16)	ND(<1 6)	ND(<26)	ND(<0 66)	ND(<6 6)
Butyl benzyl phthalate	ND(<33)	12	ND(<13)	ND(<16)	ND(<1 6)	ND(<26)	ND(<0 66)	ND(<6 6)
Diethyl phthalate	ND(<33)	ND(<3 3)	ND(<13)	ND(<16)	ND(<1 6)	ND(<26)	ND(<0 66)	ND(<6 6)
Di-n-octyl phthalate	ND(<33)	6 1	ND(<13)	ND(<16)	ND(<1 6)	ND(<26)	ND(<0 66)	ND(<6 6)
N-Nitrosodiphenylamine	ND(<33)	9 3	ND(<13)	ND(<16)	ND(<1 6)	34	ND(<0 66)	ND(<6 6)
Dibenzofuran	ND(<33)	ND(<3 3)	ND(<13)	140	5 5	ND(<26)	ND(<0 66)	ND(<6 6)
2 4-Dimethylphenol	ND(<33)	ND(<3 3)	ND(<13)	ND(<16)	ND(<1 6)	87	ND(<0 66)	ND(<6 6)
Phenol	ND(<33)	20	57	22	ND(<1 6)	640	ND(<0 66)	97
2-Methylphenol	ND(<33)	ND(<3 3)	ND(<13)	ND(<16)	ND(<1 6)	81	ND(<0 66)	ND(<6 6)
4-Methylphenol	ND(<33)	ND(<3 3)	ND(<13)	ND(<16)	ND(<1 6)	170	ND(<0 66)	15
PESTICIDES AND PCBS								
alpha-BHC	ND(<0 8)	ND(<0 8)	ND(<8 0)	ND(<0 4)	ND(<0 04)	ND(<0 80)	ND(<0 38)	ND(<0 08)
Gamma-BHC	ND(<0 8)	ND(<0 8)	ND(<8)	0 49	0 057	ND(<0 8)	ND(<0 38)	ND(<0 08)
4 4'-DDD	ND(<1 6)	ND(<1 6)	ND(<16)	1 2	ND(<0 08)	ND(<1 6)	ND(<1 16)	ND(<0 16)
4 4'-DDE	ND(<1 6)	ND(<1 6)	ND(<16)	ND(<0 8)	ND(<0 08)	ND(<1 6)	ND(<1 16)	ND(<0 16)
4 4'-DDT	ND(<1 6)	ND(<1 6)	ND(<16)	2 1	0 5	ND(<1 6)	ND(<1 16)	ND(<0 16)
Dieldrin	ND(<1 6)	ND(<1 6)	ND(<16)	ND(<1 0)	0 25	ND(<1 6)	ND(<0 16)	ND(<0 16)
Aroclor 1232	ND(<8 0)	ND(<8 0)	ND(<80)	ND(<4)	ND(<0 4)	11	ND(<0 8)	ND(<0 8)
Aroclor 1242	ND(<8 0)	ND(<8 0)	ND(<80)	7 6	ND(<0 4)	ND(<8 0)	ND(<0 8)	ND(<0 8)
Aroclor 1260	ND(<16)	ND(<16)	ND(<160)	ND(<8 0)	ND(<0 8)	34	ND(<1 6)	7 8

Chemical Name	64035-053 DS-6 Dike 1004	64035-019 DS-7 Dike 1003	64035-025 DS-8 Dike 82	64035-026 DS-8 Dike 2081	64035-042 DS-8 Dike 2083	64035-064 DS-9 Dike 92	64035-067 DS-9 Dike 2091
Depth of Sample	20-24'	7-9'	3-8	8-10	12 14	3 9	12 14
Sample Description	Soil	Waste	Soil/ Sludge	Sludge	Soil/ Organic	Sludge	Soil
VOLATILE ORGANIC FRACTION							
Benzene	ND(<0 005)	1 0	ND(<11)	6 0	ND(<0 005)	0 076	ND(<0 005)
Chlorobenzene	ND(<0 005)	0 32	ND(<11)	ND(<0 4)	ND(<0 005)	ND(<0 05)	ND(<0 005)
Ethylbenzene	ND(<0 005)	ND(<0 15)	ND(<11)	0 6	ND(<0 005)	ND(<0 05)	ND(<0 005)
Styrene	ND(<0 005)	ND(<0 15)	230	2 1	ND(<0 005)	ND(<0 05)	ND(<0 005)
Toluene	ND(<0 005)	ND(<0 15)	ND(<11)	3 8	ND(<0 005)	0 081	ND(<0 005)
Xylene	ND(<0 005)	ND(<0 15)	47	3 7	ND(<0 005)	0 21	ND(<0 005)
Acetone	ND(<0 025)	ND(<0 75)	ND(<56)	10	ND(<0 025)	2 0	ND(<0 025)
Carbon disulfide	ND(<0 005)	ND(<0 15)	ND(<11)	0 86	ND(<0 005)	ND(<0 05)	ND(<0 005)
Methylene chloride	ND(<0 025)	33	ND(<56)	ND(<2)	ND(<0 025)	ND(<0 25)	ND(<0 025)
1 1-dichloroethene	ND(<0 005)	ND(<0 15)	ND(<11)	ND(<0 4)	ND(<0 005)	ND(<0 05)	ND(<0 005)
1 2-dichloroethane	ND(<0 005)	ND(<0 15)	ND(<11)	ND(<0 4)	ND(<0 005)	ND(<0 05)	ND(<0 005)
2-Butanone (MEK)	ND(<0 025)	ND(<0 75)	ND(<56)	2 2	ND(<0 025)	0 19	ND(<0 025)
2-Hexanone	ND(<0 01)	ND(<0 3)	ND(<23)	ND(<0 8)	ND(<0 01)	ND(<0 1)	ND(<0 01)
4-methyl-2-pentanone (MIBK)	ND(<0 01)	ND(<0 3)	ND(<23)	4 2	ND(<0 01)	1 5	0 012
SEMIVOLATILE ORGANIC FRACTION							
Acenapthene	ND(<0 33)	ND(<33)	ND(<3 3)	ND(<3 3)	ND(<0 66)	ND(<33)	ND(<0 33)
Chrysene	ND(<0 33)	ND(<33)	ND(<3 3)	4 7	ND(<0 66)	ND(<33)	ND(<0 33)
Fluorene	ND(<0 33)	ND(<33)	ND(<3 3)	ND(<3 3)	ND(<0 66)	ND(<33)	ND(<0 33)
2-Methylnaphthalene	ND(<0 33)	ND(<33)	4 9	ND(<3 3)	ND(<0 66)	ND(<33)	ND(<0 33)
Naphthalene	ND(<0 33)	ND(<33)	3 6	ND(<3 3)	ND(<0 66)	ND(<33)	ND(<0 33)
Bis-(2-ethylhexyl) phthalate	ND(<0 33)	ND(<33)	4 6	ND(<3 3)	ND(<0 66)	ND(<33)	ND(<0 33)
Butyl benzyl phthalate	ND(<0 33)	ND(<33)	ND(<3 3)	ND(<3 3)	ND(<0 66)	ND(<33)	ND(<0 33)
Diethyl phthalate	ND(<0 33)	ND(<33)	ND(<3 3)	23	ND(<0 66)	ND(<33)	ND(<0 33)
Di-n-octyl phthalate	ND(<0 33)	ND(<33)	8 0	ND(<3 3)	ND(<0 66)	ND(<33)	ND(<0 33)
N-Nitrosodiphenylamine	ND(<0 33)	ND(<33)	5 2	ND(<3 3)	ND(<0 66)	ND(<33)	ND(<0 33)
Dibenzofuran	ND(<0 33)	ND(<33)	ND(<3 3)	ND(<3 3)	ND(<0 66)	ND(<33)	ND(<0 33)
2 4-Dimethylphenol	ND(<0 33)	ND(<33)	ND(<3 3)	ND(<3 3)	ND(<0 66)	ND(<33)	ND(<0 33)
Phenol	ND(<0 33)	ND(<33)	11	6 4	ND(<0 66)	ND(<33)	ND(<0 33)
2-Methylphenol	ND(<0 33)	ND(<33)	ND(<3 3)	ND(<3 3)	ND(<0 66)	ND(<33)	ND(<0 33)
4-Methylphenol	ND(<0 33)	ND(<33)	ND(<3 3)	ND(<3 3)	ND(<0 66)	ND(<33)	ND(<0 33)
PESTICIDES AND PCBS							
alpha-BHC	ND(<0 008)	1 4	ND(<0 4)	ND(<8 0)	ND(<0 008)	ND(<0 8	ND(<0 008)
Gamma-BHC	ND(<0 008)	ND(<0 16)	ND(<0 4)	ND(<8)	0 008	ND(<0 8)	ND(<0 008)
4 4'-DDD	ND(<0 016)	ND(<0 32)	ND(<0 8)	ND(<16)	ND(<0 016)	ND(<1 6)	ND(<0 016)
4 4'-DDE	ND(<0 016)	0 78	ND(<0 8)	ND(<16)	ND(<0 016)	ND(<1 6)	ND(<0 016)
4 4'-DDT	ND(<0 016)	ND(<0 32)	ND(<0 8)	ND(<16)	ND(<0 016)	ND(<1 6)	ND(<0 016)
Dieldrin	ND(<0 016)	0 75	ND(<0 8)	ND(<16)	ND(<0 016)	ND(<1 6)	ND(<0 016)
Aroclor 1232	ND(<0 08)	ND(<1 6)	ND(<4)	ND(<80)	ND(<0 008)	ND(<8)	ND(<0 08)
Aroclor 1242	ND(<0 08)	ND(<1 6)	7 7	ND(<80)	ND(<0 08)	ND(<8)	ND(<0 08)
Aroclor 1260	ND(<0 16)	ND(<3 2)	ND(<8 0)	ND(<160)	ND(<0 16)	ND(<16)	ND(<0 16)

Note ND( ) = Not Detected (detection limit)

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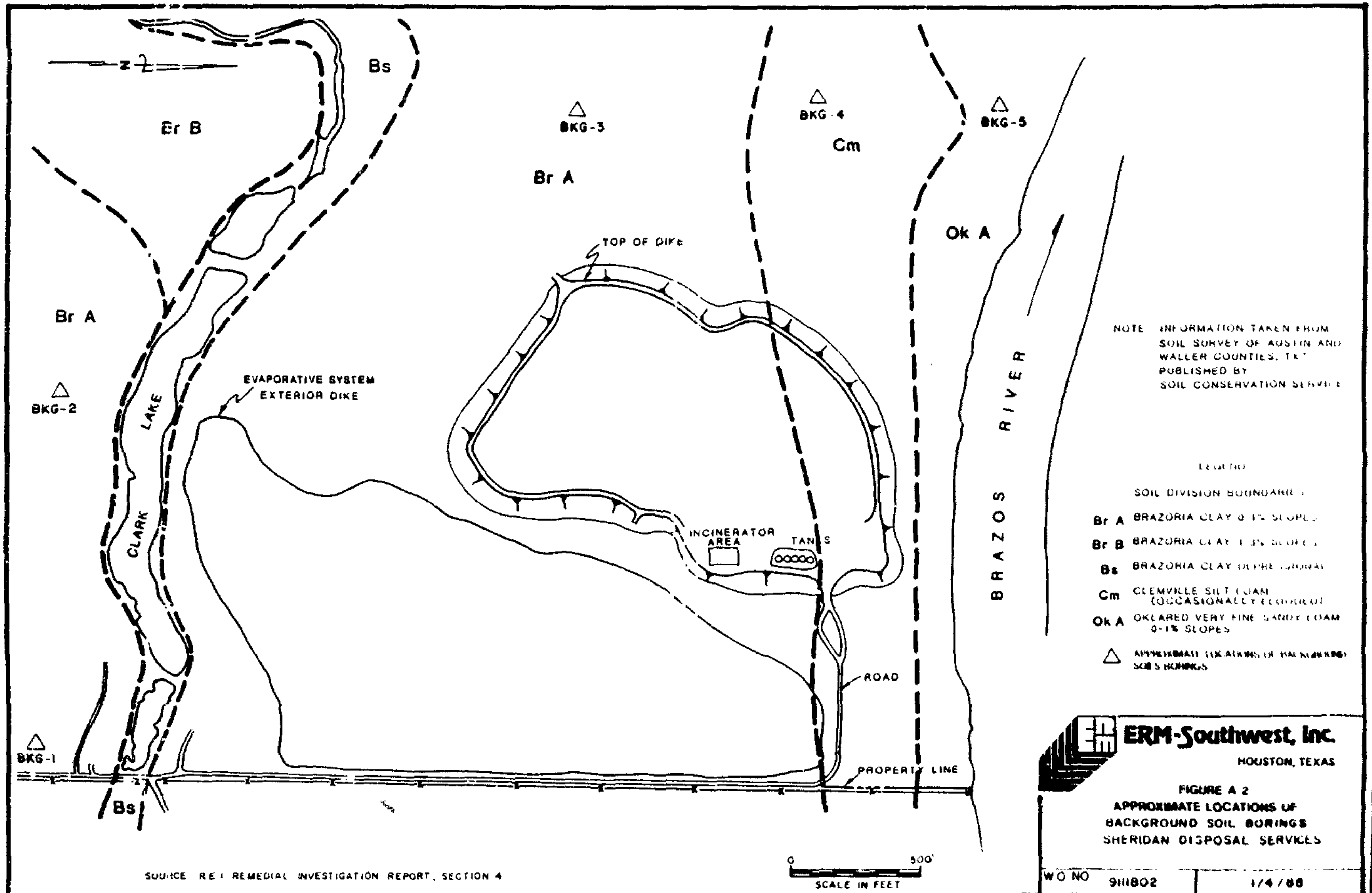

FIGURE A 2
APPROXIMATE LOCATIONS OF BACKGROUND SOIL BORINGS
SHERIDAN DISPOSAL SERVICES

TABLE A-3

SOIL BORING DESCRIPTIONS FOR SAMPLE LOCATIONS 2-19,
EVAPORATION SYSTEM

SHERIDAN DISPOSAL SERVICES SITE

Boring Number(s)	Description (0-1)	Variations
4,6,7,8,9,10,11, 12,13,14,16,17, and 18	SILTY CLAY: Medium brown, soft to stiff, roots, rootlets, shells and shell fragments, some black natural organics and coal-like fragments, no odor.	
2	SILTY CLAY: as above	Dark brown with blackish areas, slight chemical odor.
3 and 5	SILTY CLAY: as above	Slight chemical or sludge odor, black streaks in soil.
15 and 19	SILTY CLAY: as above	Odor of sludge, black steaks.

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TABLE A-4

ANALYTICAL RESULTS OF EVAPORATION SYSTEM BORINGS FOR
TOTAL METALS (IN MG/KG)

SHERIDAN DISPOSAL SERVICES SITE

Boring Number	RMAL Number	Depth (feet)	Chromium	Lead	Nickel	Zinc
EVAP-1A	65353-001	0.5-1	12	12	17	40
EVAP-1B	65353-002	2-2.5	7	9	12	27
EVAP-1C	65353-003	3-4	5	5	7	13
EVAP-1D	65353-004	5-6	10	10	13	27
EVAP-2A	65353-017	0.5-1	11	13	14	33
EVAP-3A(1)	65353-016	0.5-1	11	11	14	32
EVAP-4A	65353-012	0.5-1	11	13	16	36
EVAP-5A	65353-011	0.5-1	11	12	15	34
EVAP-6A	65353-013	0.5-1	13	13	15	39
EVAP-7A	65353-018	0.5-1	11	12	15	34
EVAP-8A	65353-010	0.5-1	13	13	17	40
EVAP-9A	65353-020	0.5-	9	12	14	[illegible]
EVAP-10A	65353-022	0.5-1	13	14	16	36
EVAP-11A	65353-021	0.5-1	10	12	14	31
EVAP-12A	65353-005	0.5-1	15	14	17	40
EVAP-13A	65353-006	0.5-1	13	11	15	40
EVAP-14A	65353-007	0.5-1	10	11	13	30
EVAP-15A(2)	65353-008	0.5-1	12	13	16	35
EVAP-16A	65353-009	0.5-1	12	11	16	34
EVAP-17A	65353-019	0.5-1	8	10	12	28
EVAP-18A	65353-014	0.5-1	11	11	14	32
EVAP-19A	65353-015	0.5-1	9	11	16	32
Duplicate 3 (EVAP-1A)	65350-028	0.5-1	14	14	20	48
Duplicate 4 (EVAP-15A)	65353-023	0.5-1	13	14	17	38
Duplicate 5 (EVAP-19A)	65353-024	0.5-1	14	13	17	38

NOTES

(1) Also reported 120 ug/kg of Aroclor 1248 (detection limit of 80 ug/kg)

(2) Also reported 110 ug/kg of Aroclor 1248 (detection limit of 80 ug/kg).

RMAL Number is the number assigned to each soil sample by Rocky Mountain Laboratories.

011072

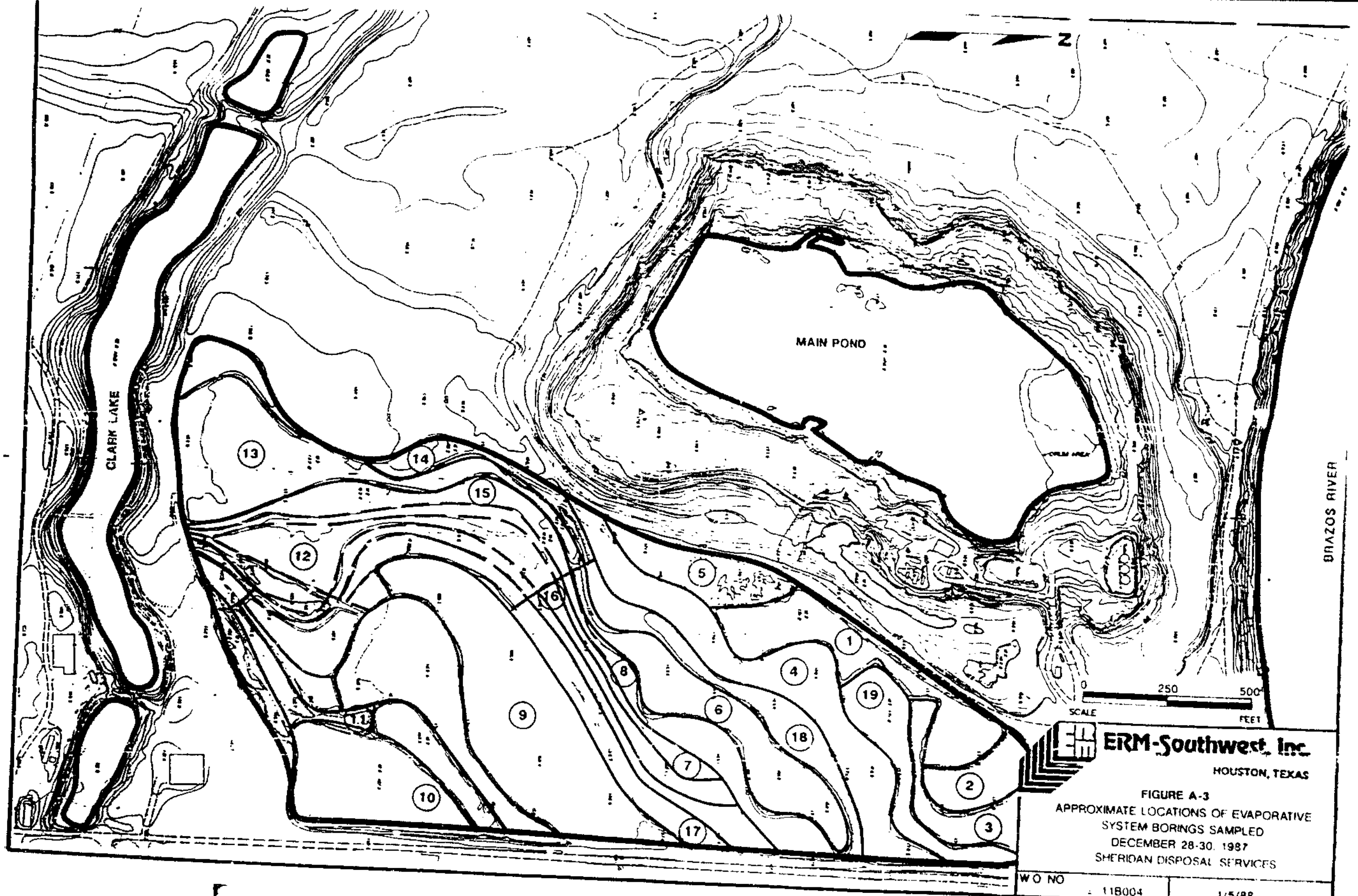


FIGURE A-3
APPROXIMATE LOCATIONS OF EVAPORATIVE
SYSTEM BORINGS SAMPLED
DECEMBER 28-30, 1987
SHERIDAN DISPOSAL SERVICES

BC96

TABLE A-5

ANALYTICAL RESULTS OF BACKGROUND BORINGS FOR
TOTAL METALS (IN MG/KG)

SHERIDAN DISPOSAL SERVICES SITE

Boring Number	RMAL Number	Depth (feet)	Chromium	Lead	Nickel	Zinc
BKG-1A	65350-001	1-1.5	16	13	19	40
BKG-1B	65350-002	4.2-4.7	15	11	17	35
BKG-1C	65350-003	6-6.5	18	13	18	40
BKG-1D	65350-004	7-7.5	16	14	17	36
BKG-1E	65350-005	9.5-10	14	14	19	36
BKG-2A	65350-006	0.5-1	14	12	16	37
BKG-2B	65350-007	2.2-2.7	7	6	9	17
BKG-2C	65350-008	4.5-5	8	7	11	20
BKG-2D	65350-009	7-7.5	6	6	8	14
BKG-2E	65350-010	9.5-10	3	ND	5	8
BKG-3A	65350-016	0.4-0.9	11	11	14	33
BKG-3B	65350-017	2.5-3	12	13	18	36
BKG-3C	65350-018	4.5-4.8	15	13	18	42
BKG-3D	65350-019	7-7.4	15	13	17	39
BKG-3E	65350-020	9.6-9.9	13	13	17	40
BKG-4A	65350-021	0.5-1	7	6	10	21
BKG-4B	65350-022	3-3.5	12	11	18	36
BKG-4C	65350-023	4.3-4.8	8	7	11	24
BKG-4D	65350-024	7-7.3	14	12	18	42
BKG-4E	65350-025	9.2-9.5	13	13	21	37
BKG-5A	65350-011	0.5-1	5	6	8	17
BKG-5B	65350-012	2.9-3.4	9	9	12	28
BKG-5C	65350-013	5-5.4	8	8	13	25
BKG-5D	65350-014	7-7.5	6	6	8	18
BKG-5E	65350-015	9-9.5	16	15	19	43
Duplicate 1 (BKG-4A)	65350-026	0.5-1	9	12	14	31
Duplicate 2 (BKG-3B)	65350-027	2.5-3	18	16	26	52

NOTE: RMAL Number is the number assigned to each soil sample by Rocky Mountain Analytical Laboratories.

011074

ATTACHMENT A

Boring Logs for Dike Borings

011075

ERM-Southwest, inc.

HOUSTON, TEXAS

DRILLING LOG

Project: Dike Borings
Owner: Sheridan
Location: Hempstead, TX
V.O. NO.: 091-11
Boring/Well No.: DS-1
Boring T.D.: 25'
Boring Diam.: 7.5"
Surface Elevation: 176.29'
Water Depth: Initial --- 24 Hrs. ---
Screen Dia.: ---
Length: ---
Slot Size: ---
Casing Dia.: ---
Length: ---
Type: ---
Drilling Company: Southwestern Labs
Drilling Method: Hollow Stem Auger
Driller: B. Christopher
Log By: S. MacDonald
Date Drilled: 7/6/87

SKETCH MAP

NOTES

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE TYPE	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0					0-25	0-8	CLAY: Reddish brown, plant roots and rootlets, stiff to 6 ft, softer to 8 ft., black organic material 6-8 ft.
5							
						8-10	SLUDGE: Black, with loose sandy or clayey matrix, strong odor.
10						10-19	CLAY: Reddish brown, stiff, with shell fragments and rootlets to 16 ft., becomes grayish black, much softer from 16-19 ft.
15							
						19-25	SANDY CLAY: Reddish brown, very sandy and loose from 19-20.5 ft., with shells and rootlets, stiffer, slightly sandy from 20.5-23 ft.; very sandy, loose and crumbly at 23-25 ft.; no discernible contamination or odor from 20-25 ft.
20							
25							T.D.=25'

011076

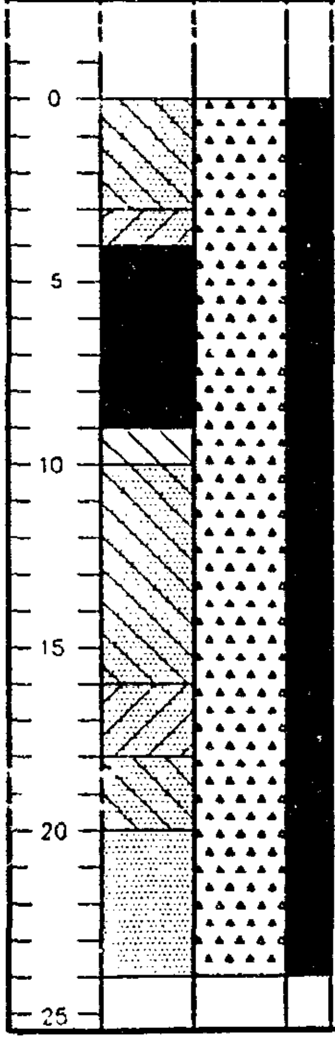
ERM-Southwest, inc.
HOUSTON, TEXAS

DRILLING LOG

Project: Oike Borings
Owner: Sheridan
Location: Hempstead, TX
V.O. NO.: 091-11
Boring/Well No.: DS-2
Boring T.D.: 24'
Boring Diam.: 7.5"
Surface Elevation: 177.8'
Water Depth: Initial --- 24 Hrs. ---
Screen Dia.: ---
Length: ---
Slot Size: ---
Casing Dia.: ---
Length: ---
Type: ---
Drilling Company: Southwestern Labs
Drilling Method: Hollow Stem Auger
Driller: B. Christopher
Log By: S. MacDonald
Date Drilled: 7/7/87

SKETCH MAP

NOTES



DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE TYPE	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0					0-24	0-3	SANDY CLAY: Reddish brown, very sandy, rootlets, black organic-looking material, moist.
						3-4	CLAYEY SAND: Grayish, some odor.
5						4-9	SLUDGE: Black, with free oil (blue and green), some yellow grease spots.
						9-10	CLAY: Reddish brown with black streaks, odor.
10						10-16	SANDY CLAY: Reddish brown, very sandy, few organic speckles and rootlets, becomes less cohesive from 12-14 ft., contains a shell hash layer from 14-16 ft.
15						16-18	SLIGHTLY CLAYEY SAND: Reddish brown, loose, dry.
						18-20	SANDY CLAY: Brown to reddish brown, stiff.
20						20-24	SAND: Grayish, loose, dry, slight odor at 20 ft., but no discernible odor from 22-24 ft.
25							T.D.=24'

011077

ERM-Southwest, inc.
HOUSTON, TEXAS

DRILLING LOG

Project	Oke Borings	Owner	Sheridan
Location	Hempstead, TX	V.O. NO.	C91-11
Boring/ Well No.	DS-3	Boring T.D.	24 '
		Boring Diam.	7.5 "
Surface Elevation	177.5'	Water Depth: Initial	---
		24 Hrs.	---
Screen Dia.	---	Length	---
		Slot Size	---
Casing Dia.	---	Length	---
		Type	---
Drilling Company	Southwestern Labs	Drilling Method	Hollow Stem Auger
Driller	B. Christopher	Log By	S. MacDonald
		Date Drilled	7/7/87

SKETCH MAP

NOTES

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE TYPE	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0					0-24	0-3	VERY SANDY CLAY: Reddish brown, stiff to loose, black organic speckles, rootlets.
						3-4	CLAYEY SAND: Gray, moist, odor.
5						4-8	SLUDGE: Black, free oil present in blue and green hues, also yellow grease spots.
10						8-12	SANDY CLAY: Reddish brown, stiff with some black staining from 8-10 ft., becomes loose and very sandy from 10-12 ft.
15						12-18	VERY CLAYEY SAND: Reddish, very loose.
						18-20	CLAY: Reddish brown, stiff.
20						20-24	SAND: Red, slightly clayey, damp, loose.
25							T.D.=24 '

011078

ERM-Southwest, inc.

HOUSTON, TEXAS

DRILLING LOG

Project	Dike Borings	Owner	Sheridan
Location	Hempstead, TX	V.O. NO.	091-11
Boring/ Well No.	DS-4	Boring T.D.	24 ' Boring Diam. 7.5 "
Surface Elevation	175.7'	Water Depth: Initial	--- 24 Hrs. ---
Screen Dia.	---	Length	--- Slot Size ---
Casing Dia.	---	Length	--- Type ---
Drilling Company	Southwestern Labs	Drilling Method	Hollow Stem Auger
Driller	B. Christopher	Log By	S. MacDonald Date Drilled 7/7/87

SKETCH MAP

NOTES

011079

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE TYPE	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0					0–24	0–4	CLAY: Reddish brown, stiff, with black organic sludge streaks throughout.
5						4–9	SLUDGE: Black with clayey to sandy clay matrix, few spots of free oil.
10						9–14	CLAY: Reddish brown, stiff, greasy texture with black organic particles from 12 – 14 ft.
15						14–16	SANDY CLAY: Gray to black, oil droplets throughout.
						15–24	SLIGHTLY CLAYEY SAND: Reddish brown, slight odor from 16–18 ft., no odor from 20–24 ft., becomes clayier at 23 ft.
20							
25							T.D.=24 '

PAGE 1 OF 1

ERM-Southwest, inc.

HOUSTON, TEXAS

DRILLING LOG

Project: Zike Borings
Owner: Sheridan
Location: Hempstead, TX
V.O. NO.: 091-11
Boring/Well No.: OS-5
Boring T.D.: 25 '
Boring Diam.: 7.5 "
Surface Elevation: 177.4'
Water Depth: Initial --- 24 Hrs. ---
Screen Dia.: ---
Length: ---
Slot Size: ---
Casing Dia.: ---
Length: ---
Type: ---
Drilling Company: Southwestern Labs
Drilling Method: Hollow Stem Auger
Driller: B. Christopher
Log By: D. Weldemann
Date Drilled: 7/10/87

SKETCH MAP

NOTES

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE TYPE	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0					0-25	0-5	SANDY CLAY: Medium brown to red, roots from 0-1 ft., black stains from 1-3 ft., soft, moist; has a dry, stiff clay layer around 3 ft.
5						5-10	SLUDGE: Silvery gray, gooey, with some sand particles. HNU = 180-200 ppm.
10						10-11.5	SILTY CLAY: Dark brown, some black staining.
						11.5-19	CLAY: Reddish brown, dry, stiff, occasional slickensides from 15-19 ft., few metal pieces (from barrels?) within.
15							
						19-20	SANDY CLAY: Medium to dark brown, moist to damp.
20						20-21	SILTY SANDY CLAY: Dark brown to black, dry, stiff.
						21-23	SLIGHTLY SANDY CLAY: Reddish brown, whitish staining within, dry, stiff.
						23-25	SAND: Light reddish, fine-grained, dry, unconsolidated.
25							T.D.=25 '

011080

ERM-Southwest, inc.

HOUSTON, TEXAS

DRILLING LOG

Project: Dike Borings	Owner: Sheridan
Location: Hempstead, TX	V.O. NO. 091-11
Boring/Well No.: DS-6	Boring T.D. 24 ' — Boring Diam. 7.5 "
Surface Elevation: 177.4'	Water Depth: Initial --- — 24 Hrs. ---
Screen Dia. ---	Length --- — Slot Size ---
Casing Dia. ---	Length --- — Type ---
Drilling Company: Southwestern Labs	Drilling Method: Hollow Stem Auger
Driller: B. Christopher	Log By D. Weidemann — Date Drilled 7/10/87

SKETCH MAP

NOTES

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE TYPE	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0					0-24	0-2	SLIGHTLY SANDY CLAY: Reddish brown, roots, few black speckles, dry.
						2-3.5	SANDY SILTY CLAY: Reddish brown, softer than above, some black staining, slight odor.
5						3.5-9	SLUDGE: Black, soft, very sticky from 6-7 ft., occasional reddish clay througnout, odoriferous.
10						9-11.5	SANDY CLAY: Medium brown, dry, stiff, becomes softer with depth, odor like burnt plastic from within, occasional sand pockets, rootlets, whitish-yellow staining or crystallization.
						11.5-15.5	CLAY: Medium brown, some blackish stains, occasional slickensides.
15						15.5-17.5	SANDY CLAY: Reddish brown to dark brownish black, sand is fine to medium grained, increasing sand content with depth.
						17.5-19	CLAYEY SAND: Reddish brown to dark brown, dry, soft, very slight chemical odor throughout.
						19-20	CLAY: Brownish red, slightly sandy, dry, stiff.
20						20-23.5	CLAYEY SAND: Red, soft, unconsolidated, some vertical pores, some areas of linear whitish staining.
						23.5-24	CLAY: Brownish red, slightly sandy, dry, stiff.
25							T.D.=24 '

011081

ERM-Southwest, inc.
HOUSTON, TEXAS

DRILLING LOG

Project	Dike Borings	Owner	Sheridon
Location	Hempstead, TX	V.O. NO.	091-11
Boring/ Well No.	DS-7	Boring T.D.	20 ' Boring Diam. 7.5 "
Surface Elevation	179.2'	Water Depth: Initial	--- 24 Hrs. ---
Screen Dia.	---	Length	--- Slot Size ---
Casing Dia.	---	Length	--- Type ---
Drilling Company	Southwestern Labs	Drilling Method	Hollow Stem Auger
Driller	B. Christopher	Log By	S. MacDonald Date Drilled 7/8/87

SKETCH MAP

NOTES

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE TYPE	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0					0-20	0-3	SLIGHTLY SANDY CLAY: Reddish brown to brown, stiff to crumbly at 0-1 ft., becomes stiff with depth, strong odor, rootlets.
						3-4	VERY SANDY CLAY: Reddish brown, no discernible odor.
5						4-7	CLAY: Brownish, only slightly sandy, rootlets, slight odor and organic streaking.
						7-9	FLY ASH & SLUDGE: Black, odor, appearance of lava.
10						9-14	SANDY CLAY: Brown, moist, no discernible odor.
15						14-16	VERY CLAYEY SAND: Reddish brown, no odor.
						16-20	VERY SANDY CLAY: Reddish brown, no odor.
20							T.D.=20 '
25							

011082

ERM-Southwest, inc.
HOUSTON, TEXAS

DRILLING LOG

Project DSe Borings Owner Sheridan
Location Hempstead, TX V.O. NO. 091-11
Boring/Well No. DS-8 Boring T.D. 24' Boring Diam. 7.5"
Surface Elevation 179.4' Water Depth: Initial --- 24 Hrs. ---
Screen Dia. --- Length --- Slot Size ---
Casing Dia. --- Length --- Type ---
Drilling Company Southwestern Labs Drilling Method Hollow Stem Auger
Driller B. Christopher Log By S. MacDonald Date Drilled 7/8/87

SKETCH MAP

NOTES

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE TYPE	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0					0-24	0-3	SANDY CLAY: Reddish brown, rootlets, some black organic speckles.
						3-8	CLAY: Brown, with some sand, very strong ammonia-like odor, black organic material throughout.
5							
						8-10	SLUDGE: Black.
10						10-12	VERY CLAYEY SAND: Reddish brown, crumbly, dry.
						12-14	CLAY: Brown with black organic material througnout, very stiff.
						14-16	CLAYEY SAND: Reddish brown.
15						16-18	SANDY CLAY: Reddish brown, stiff.
						18-20	SLIGHTLY CLAYEY SAND: Reddish brown, loose, dry.
20						20-23.5	CLAY: Reddish brown, stiff, rootlets.
						23.5-24	SLIGHTLY CLAYEY SAND: Reddish brown, very minor clay component. T.D.= 24'
25							

011083

ERM-Southwest, inc.
HOUSTON, TEXAS

DRILLING LOG

Project: Dike Borings	Owner: Sheridan
Location: Hempstead, TX	V.O. NO. 091-11
Boring/Well No. DS-9	Boring T.D. 24' — Boring Diam. 7.5"
Surface Elevation 175.6'	Water Depth: Initial --- 24 Hrs. ---
Screen Dia. ---	Length --- Slot Size ---
Casing Dia. ---	Length --- Type ---
Drilling Company Southwestern Labs	Drilling Method Hollow Stem Auger
Driller B. Christopher	Log By D. Weldemann — Date Drilled 7/10/87

SKETCH MAP

NOTES

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE TYPE	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0					0-24	0-3	VERY SANDY CLAY: Reddish brown, soft to slightly stiff, abundant roots, few black speckles.
						3-9	SLUDGE: Black, very strong odor, clayey and dry from 3-6 ft., very moist to saturated matrix from 6-9 ft., streaks of brown soil from 6-9 ft., few pieces of glass within.
5							
						9-10	CLAY: Reddish brown, rootlets, slickensides.
10						10-12	VERY SANDY CLAY: Reddish brown.
						12-14	SLIGHTLY CLAYEY SAND: Reddish brown, dry, HNU = 0 ppm.
						14-16.5	SANDY CLAY: Reddish brown, few black organic speckles.
15							
						16.5-18.7	SAND: Reddish, fine-grained, dry, unconsolidated.
						18.7-19.5	CLAYEY SAND: Reddish, dry.
20						19.5-21.5	SANDY CLAY: Reddish, dry, some vertical pores, few white speckles.
						21.5-22.5	CLAYEY SAND: Reddish, dry.
						22.5-24	SAND: Red, very fine-grained, dry, unconsolidated, HNU = 0 ppm. T.D.=24'
25							

ATTACHMENT B

Boring Logs for Background and
Selected Evaporation System Borings

011085

D642

ERM-Southwest, inc.
HOUSTON, TEXAS

DRILLING LOG

Project: Background Borings
Owner: Sheridan
Location: Hempstead, TX
V.O. NO.: 091-11
Boring/Well No.: BKG-1
Boring T.D.: 10'
Boring Diam.: 7"
Surface Elevation: ---
Water Depth: Initial --- 24 Hrs. ---
Screen Dia.: ---
Length: ---
Slot Size: ---
Casing Dia.: ---
Length: ---
Type: ---
Drilling Company: Southwestern Labs
Drilling Method: Hollow Stem Auger
Driller: Steve Bender
Log By: D. Weidemann
Date Drilled: 12/28/87

SKETCH MAP

NOTES

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE TYPE	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0					0-2	0-2	SILTY CLAY: Dark reddish brown; soft at top, becomes stiffer with depth; rootlets at surface; carbonate nodules at 2 ft.
					2-4	2-4	NO RECOVERY
5					4-10	4-9	SANDY CLAY: Dark brown; dry; stiff; few rootlets; abundant carbonate nodules; sand content decreases from 6.5'-7.5'; fewer carbonate nodules with depth.
10						9-10	CLAY: Reddish brown; trace of sand; slickensided surfaces (probably due to compaction during sampling). T.D.=10'
15							
20							
25							

011086

BK1

ERM-Southwest, inc.
HOUSTON, TEXAS

DRILLING LOG

Project	Background Borings	Owner	Sheridon
Location	Hempstead, TX	V.O. NO.	091-11
Boring/ Well No.	BKG-2	Boring T.D.	10 '
		Boring Diam.	7 "
Surface Elevation	---	Water Depth: Initial	---
		24 Hrs.	---
Screen Dia.	---	Length	---
		Slot Size	---
Casing Dia.	---	Length	---
		Type	---
Drilling Company	Southwestern Labs	Drilling Method	Hollow Stem Auger
Driller	Steve Bender	Log By	D. Weidemann
		Date Drilled	12/28/87

SKETCH MAP

NOTES

DEPTH (FEET)	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0		0-1	0-1	SILTY CLAY: Reddish brown; soft near top, becomes stiffer with depth; roots & rootlets; rare carbonate nodules.
		1-2	1-2	NO RECOVERY
		2-5	2-3.6	SANDY CLAY: Dark Brown to reddish brown; moist at top, dry at base; sand is fine-grained.
			3.6-5	SILTY SAND: Reddish brown; dry; fine-grained; hard from 4'-5' with some carbonate staining.
5	7,8,8	5-7	5-7	SANDY CLAY: Reddish brown; dry; hard.
		7-10	7-8	SILTY SAND: Reddish brown; fine-grained; moist to damp; slightly cohesive.
			8-10	SAND: Reddish brown; fine-grained; damp; non-cohesive.
10				T.D.=10 '
15				
20				
25				

BK2

PAGE 1 OF 1

011087

ERM-Southwest, inc.
HOUSTON, TEXAS

DRILLING LOG

Project: Background Borings
Owner: Sheridon
Location: Hempstead, TX
W.O. NO.: 091-11
Boring/Well No.: BKG-3
Boring T.D.: 10'
Boring Diam.: 7"
Surface Elevation: ---
Water Depth: Initial: ---
24 Hrs.: ---
Screen Dia.: ---
Length: ---
Slot Size: ---
Casing Dia.: ---
Length: ---
Type: ---
Drilling Company: Southwestern Labs
Drilling Method: Hollow Stem Auger
Driller: Steve Bender
Log By: D. Weidemann
Date Drilled: 12/29/87

SKETCH MAP

NOTES

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE TYPE	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0					0-0.9	0-0.9	SILTY CLAY: Dark brown; moist; sticky; roots and rootlets.
					0.9-2	0.9-2	NO RECOVERY
					2-10	2-10	SILTY CLAY: Dark reddish brown; very stiff; few carbonate nodules, gastropod shells and other shell fragments; From 4'-6': becomes less silty with thin layers of carbonate deposition; becomes drier and more crumbly with some slickensides; From 6'-8': occasional rootlets and black natural organic areas; From 8'-10': occasional sand pockets and a thin silt layer at 9.6'.
5							
10							T.D.=10'
15							
20							
25							

BK3

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HOUSTON, TEXAS

DRILLING LOG

Project: Background Borings
Owner: Sheridon
Location: Hempstead, TX
V.O. NO.: 091-11
Boring/Well No.: BKG-4
Boring T.D.: 10'
Boring Diam.: 7"
Surface Elevation: ---
Water Depth: Initial: --- 24 Hrs.: ---
Screen Dia.: ---
Length: ---
Slot Size: ---
Casing Dia.: ---
Length: ---
Type: ---
Drilling Company: Southwestern Labs
Drilling Method: Hollow Stem Auger
Driller: Steve Bender
Log By: D. Weidemann
Date Drilled: 12/29/87

SKETCH MAP

NOTES

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE TYPE	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0					0-10	0-1.7	SANDY SILTY CLAY: Reddish brown; damp to moist; sand lense at 1 ft.
						1.7-2.3	CLAY: Dark reddish-brown; roots and rootlets; black organic material.
						2.3-3.7	SLIGHTLY SANDY CLAY: Light reddish-brown; dry; cohesive but crumbly; sand in pockets; rootlets.
						3.7-4	SAND: Light red; fine-grained; dry; cohesive.
						4-4.3	SLIGHTLY SANDY CLAY: Light reddish brown; dry; cohesive; sand in pockets.
5						4.3-4.8	SAND: Light brown; dry; crumbly.
						4.8-6	CLAY: Dark red to brown; dry; hard; carbonate nodules; rootlets.
						6-10	SILTY CLAY: Dark reddish brown; dry; stiff; rootlets; carbonate nodules; at 8' have a 0.02' layer of sand with light gray calcareous (?) material.
10							T.D.=10'
15							
20							
25							

BK4

011089

ERM-Southwest, inc.

HOUSTON, TEXAS

DRILLING LOG

Project: Background Borings	Owner: Sheridan
Location: Hempstead, TX	V.O. NO. 091-11
Boring/Well No. BKG-5	Boring T.D. 10' Boring Diam. 7"
Surface Elevation ---	Water Depth: Initial --- 24 Hrs. ---
Screen Dia. ---	Length --- Slot Size ---
Casing Dia. ---	Length --- Type ---
Drilling Company Southwestern Labs	Drilling Method Hollow Stem Auger
Driller Steve Bender	Log By D. Weidemann Date Drilled 12/28/87

SKETCH MAP

NOTES

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE TYPE	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0					0-10	0-2.6	SILTY SAND: Reddish brown; moist to damp; roots and rootlets; layer of wet sand from 2'-2.2'.
						2.6-3.5	SANDY CLAY: Dry; stiff; roots.
						3.5-4	SILTY SAND: Reddish brown; damp; layer of dark reddish brown clay from 3.9'-4'.
5						4-6.3	SLIGHTLY CLAYEY SAND: Alternating layers (0.2'-0.3' thick) of medium to light reddish fine-grained sand with some clay and slightly sandy clay; roots.
						6.3-10	SILTY CLAY: Dark reddish brown; trace of sand; carbonate nodules and rootlets throughout; some slickensides from 8'-10'.
10							T.D.=10'
15							
20							
25							

BKS

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ERM-Southwest, inc.
HOUSTON, TEXAS

DRILLING LOG

Project: Evaporation Borings
Owner: Sheridan
Location: Hempstead, TX
V.O. NO.: 091-11
Boring/Well No.: EVAP-1A
Boring T.D.: 6'
Boring Diam.: 7"
Surface Elevation: ---
Water Depth: Initial --- 24 Hrs. ---
Screen Dia.: ---
Length: ---
Slot Size: ---
Casing Dia.: ---
Length: ---
Type: ---
Drilling Company: Southwestern Labs
Drilling Method: Hollow Stem Auger
Driller: Steve Bender
Log By: D. Weidemann
Date Drilled: 12/29/87

SKETCH MAP

NOTES

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE TYPE	COHESIVE STRENGTH (tons/sq.ft.) or Penetration Test (Blows per 6")	SAMPLE INTERVAL (FEET)	DESCRIPTION INTERVAL (FEET)	DESCRIPTION/SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURE)
0					0-6	0-2	SILTY CLAY: Very dark brown; sludge-like areas with black streaking; moist; roots, rootlets; few gastropod shells; some odor.
						2-2.5	SANDY CLAY: Dark brown; rootlets; odor
						2.5-4.6	SILTY SAND: Brown; moist to wet; rootlets; odor.
5						4.6-6	SILTY CLAY: Dark brown; dry, stiff; abundant carbonate nodules near 6 ft.; strongest odor of all samples. T.D.=6
10							
15							
20							
25							

EVI

011091

APPENDIX B

Phase I Treatability Study

0110920

PHASE I
BIOLOGICAL TREATABILITY REPORT
FOR
SOURCE CONTROL FEASIBILITY STUDY

Sheridan Site Committee
Sheridan Disposal Services Site
Hempstead, Texas

011093

Bruce H. Clarke

Bruce H. Clarke

February 9, 1988

W.O. #91-12

Revised June 9, 1988

2nd Revision August 30, 1988

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E718

TABLE OF CONTENTS

SUMMARY

Laboratory biological treatment studies were conducted on sludge and pond water obtained from the Sheridan Disposal Site (SDS) to provide a preliminary assessment of the potential for biodegradation of organic constituents at the site. It was not the intention of these studies to generate detailed design data, nor provide specific degradation rates. The studies demonstrated that concentrations of volatile and semi-volatile hazardous organic substances in the Sheridan sludge may be reduced via a biotreatment process. A portion of such removal is attributable to volatilization. Concentrations of all detected hazardous organic substances showed reductions, most to below detection limits. Polychlorinated biphenyls (PCBs), however, were detected in the final samples.

Biodegradation of the pond sludge from the SDS site was tested in 77-day suspended growth, mixed reactor tests. Six reactors were seeded with an acclimated culture of native organisms. The reactors were filled with pond water and loaded with pond sludge. Samples of the mixed liquor from each reactor were collected periodically throughout the study and analyzed to assess the degree of degradation of Hazardous Substance List (HSL) organics including PCBs. Because the initial concentration of Aroclor 1260 was just above the detection limit, there was concern that any significant amount of degradation could not be quantified. Therefore, the raw sludge was spiked with Aroclor 1260 to a total concentration of about 100 ppm.

During the study, a phase separation occurred which resulted in the formation of tar balls in the bottoms of the reactors. Although this unexpected phase separation made it difficult to quantify the exact extent of PCB degradation, it was apparent that each of the HSL organics which were originally detected in the sludge were degraded in the reactors to some extent. Biological treatment reduced the pond sludge volume by approximately 50% and produced a dense tar-like hydrophobic residue.

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PHASE I
BIOLOGICAL TREATABILITY REPORT
FOR
SOURCE CONTROL FEASIBILITY STUDY

1 - INTRODUCTION

1.1 Treatment Concepts

Suspended growth reactors rely on microorganisms suspended in an aqueous solution to degrade organic constituents. Key parameters which are frequently controlled in such reactors include temperature, pH, residence time, nutrient concentrations, oxygen concentration, mixing energy and organic loading. They can be operated as batch or continuous flow reactors. In this study batch reactors with mechanical mixers and diffused aeration were used.

Acute toxicity is a toxic effect resulting from a single short-term exposure. Acute toxicity in a biological treatment reactor can result in severely slowed biodegradation rates or, in extreme cases, complete inhibition of microbial growth.

Aerobic operation of the reactors refers to a mode of operation in which the oxygen concentration is consistently maintained at a level which will not limit aerobic biodegradation. This has typically been defined as 2 ppm for domestic wastewater treatment systems and that same value was assumed to be valid for this study.

Aerobic/anoxic cycling refers to a mode of operation in which the oxygen concentration in the reactor is maintained above 2 ppm for a period of time followed by a period in which mixing and aeration are halted and the oxygen concentration is allowed to approach zero. Anaerobic biodegradation proceeds along different pathways than aerobic biodegradation and thereby can frequently degrade compounds which are not degradable aerobically. Cycling the reactors allows both types of pathways to interact in degradation of the sludge.

An acclimated culture is one which has been allowed to grow in the medium to be tested under conditions similar to those which exist in the test.

1.2 Benefit of Technology

The potential benefit of using biological treatment is the removal/destruction of mobile, biodegradable organic constituents from the SDS pond sludge. This would reduce the mobility, toxicity and volume of the sludge prior to closure. Based on visual observation, the remaining residue is expected to be easily dewatered due to its hydrophobic nature.

The benefit of using suspended growth reactors for treatment of the pond sludge is that it provides excellent contact between the microorganisms and the soluble organic constituents which are being degraded. Such a system is normally easy to control because it will tend to be very homogenous, thus nutrient addition and pH control are fairly simple to implement. In addition the dilution effect of the reactor water reduces any acute toxicity effects of the sludge on the microorganisms.

1.3 Objectives, Limitations

The objective of biological treatment is to reduce the mobility, toxicity and volume of the pond sludge prior to its final disposition by biodegrading mobile and toxic organic constituents and dewatering the remaining residue. There are several factors which limit the ability of biodegradation to accomplish these objectives. The sludge has an inorganic solids content which limits the volume reduction which can be accomplished. The sludge also appears to contain a high percentage of high molecular weight organic compounds which re hydrophobic in nature and resistant to biodegradation.

The objectives of this study were to: 1) assess any acute toxicity impacts of the pond water, 2) demonstrate that biological treatment has potential for reducing the toxicity and volume of the sludge and 3) gain some preliminary data on what the practical constraints of such a treatment system would be. This study was not intended to provide detailed design data or degradation rate constants for the sludge.

The term acute toxicity as it is used above refers to the tendency of the pond water to prohibit biological activity. The acute toxicity test described in Section 2 was conducted to determine if the pond water alone would prohibit biodegradation.

2.1 Methods

The laboratory evaluation of biodegradation as an applicable treatment technology for the sludge and soil at the Sheridan Disposal Site (SDS) was conducted in three steps:

1. Pond water acute toxicity testing
2. Microbial acclimation
3. Sludge biodegradation testing

2.1.1 Pond Water Acute Toxicity Testing

Pond water acute toxicity testing was conducted for 21 days, prior to the start of the microbial degradation test as follows:

- One gallon of pond water was placed in an open top container and approximately three tablespoons of microbial seed material was added. The seed material consisted of soil from the edge of the SDS pond, soil from the edge of Clark Lake and sludge from an active oily industrial waste biodegradation pond.

- Aeration was by means of a mechanical mixer and a submerged air stone. Dissolved oxygen content was targeted for 6.0 mg/L but, due to low biological activity, higher concentrations could not be avoided.

- Nutrients were added to the pond water to assure an excess of nitrogen and phosphorous.

- Grab Samples were taken on days -21, -14, -7, and 0. Samples were analyzed for the parameters indicated in Table 2-1.

- Data was analyzed for signs of microbial activity.

2.1.2 Microbial Acclimation

The microbial acclimation was conducted for 21 days prior to the start of the biological degradation test as follows:

- Approximately one-quarter pound of seed material (see above) was placed in a five gallon, open top container and three to four pounds of sludge were added. Pond water was added to bring the total volume to four gallons.

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TABLE 2-1

ANALYTICAL PARAMETERS
AND METHODS

Constituent	EPA[a] Method	Standard[b] Method	Toxicity Testing	Bio-degradation Testing
TOC	415.1/9060		X	X
Oil and Grease	413.1		X	X
BOD_5	405.1		X	X
TSS	160.2		X	X
VSS	--	209.D	X	X
D.O.	--	422.F	X	X
D.O. Uptake	--	213.B	X	X
Cl^-	300.0		X	X
$SO_4^{=}$	300.0		X	X
Dissolved NH_4-N	350.1		X	X
TKN	351.2		X	X
P	365.2		X	X
K	200.7		X	X
HSL-Volatile Organics	8240			X
HSL-Semi-Volatile Organics	8270			X
HSL-Pesticides and PCBs	8080			X
PCB Congeners	680 (Customized)			X

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Sources: a) U.S. Environmental Protection Agency SW-846, 3rd Edition, November, 1986

b) APHA, Standard Methods for the Examination of Water and Wastewater, 15th Edition, Washington, D.C., American Public Health Assoc., 1980.

- Mixing was accomplished using a 2-inch diameter propeller on a shaft connected to a 1/20 hp variable speed mixer.

- During the acclimation period, D.O. and pH were monitored daily and controlled between 2.0 and 6.0, and 6 and 9, respectively.

- Nutrients were added to assure an excess of nitrogen and phosphorous.

- The acclimated culture served as seed material for the test reactors.

2.1.3 Sludge Biodegradation Test

The sludge biodegradation study was conducted for 77 days as follows:

- Six 17-gallon reactors were set up according to Table 2.2.

- Mixing was accomplished with 1/20 hp mechanical mixers with 2-inch diameter propellers. Motors were later upgraded to 1/15 hp.

- D.O., pH and temperature were monitored daily. D.O. was maintained between 2 and 6 ppm by diffusing air into the reactors on an as-needed basis, with air flows adjusted daily.

- The solids for the reactors were from a composite sludge sample taken from 15 locations in the SDS pond.

- Nutrients were added to assure an excess of nitrogen and phosphorous.

- The room was kept at a temperature of 72 $^{o}F \pm 5^{o}$.

- The pH was maintained between 6.5 and 9 by addition of 0.1 normal phosphoric acid or sodium hydroxide as needed.

- Water levels were adjusted by adding distilled water to adjust back to the no evaporation level.

- Samples were obtained by first scraping the sides and bottom of the reactor to resuspend any settled material. With the mixer turned on high-speed, a grab

TABLE 2-2

BIOLOGICAL TREATMENT
TEST SCENARIOS

Reactor No.	Reactor Set Up
1	0% SS[a] (Pond Water)
2	0.5% SS
3	1.0% SS
4	5.0% SS
5	0.5% SS, 1.0% SS added every seven days to a maximum of 4.5% SS
6	1.0% SS aerobic/anoxic seven-day intervals

[a] SS = Sludge Solids.

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sample was then collected for each reactor. If multiple sample containers were required for a reactor, each container was filled from a separate sample.

- After sampling, the air and mixer was turned off and the new water level marked.

2.2 Test Results

2.2.1 Acute Toxicity Test Results

Acute toxicity testing of the pond water demonstrated that the pond water did not prohibit microbial activity. Indigenous microorganisms survived for extended periods in the pond water. During the study a significant reduction in total organic carbon concentration occurred (41%), and significant increases in total and volatile suspended solids (461% and 62%) were also observed. Based on TOC reduction, D.O. uptake measurements, and the suspended solids increase, the pond water appeared to be nontoxic. The analytical data are presented in Table 2-3. The D.O. uptake data are presented in Figure 2-1.

2.2.2 Biological Treatment Tests Results

The analytical results of the biotreatment study mixed-liquor samples for the six reactors are presented in Table 2-4. The results are segregated by reactor in that table.

The data for conventional parameters such as TSS, VSS, BOD, TOC, and oil and grease varied erratically during the study and are of marginal use in interpreting the results of the study. As the study progressed, the particle sizes of residue in each reactor varied and consequently the amount of residue in suspension in a reactor varied between sample dates. This caused variations in the analytical data.

Volatile organic compounds from the hazardous substance list (HSL) were essentially removed during the study. Semi-volatile HSL organic compounds were generally removed to below detection levels in the water phase, but as discussed later in this report their removal from the solid phase may not have been complete. With the exception of some PCBs, however, the data indicate reductions of all HSL constituents, via the biological treatment process (which includes an unquantified amount of volatilization).

For reactors 1100, 1200, and 1300, all volatile and semi-volatile HSL constituents in the water phase were reduced to below

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TABLE 2-3

ANALYTICAL DATA

ACUTE TOXICITY REACTOR

PARAMETER	Units	DAY OF STUDY 1	9	15	22
Total Organic Carbon	mg/L	440	384	310	260
Oil & Grease	mg/L	17	9	27	13
Total Suspended Solids	mg/L	70	632	541	393
Volatile Suspended Solids	mg/L	60	110	134	97
Biochemical Oxygen Demand	mg/L	11			
Chloride	mg/L	359			
Sulfate	mg/L	29			
Ammonia nitrogen	mg/L	0.8			
Total Kjeldahl Nitrogen	mg/L	7.2			
Phosphorous	mg/L	8			
Potassium	mg/L	82			

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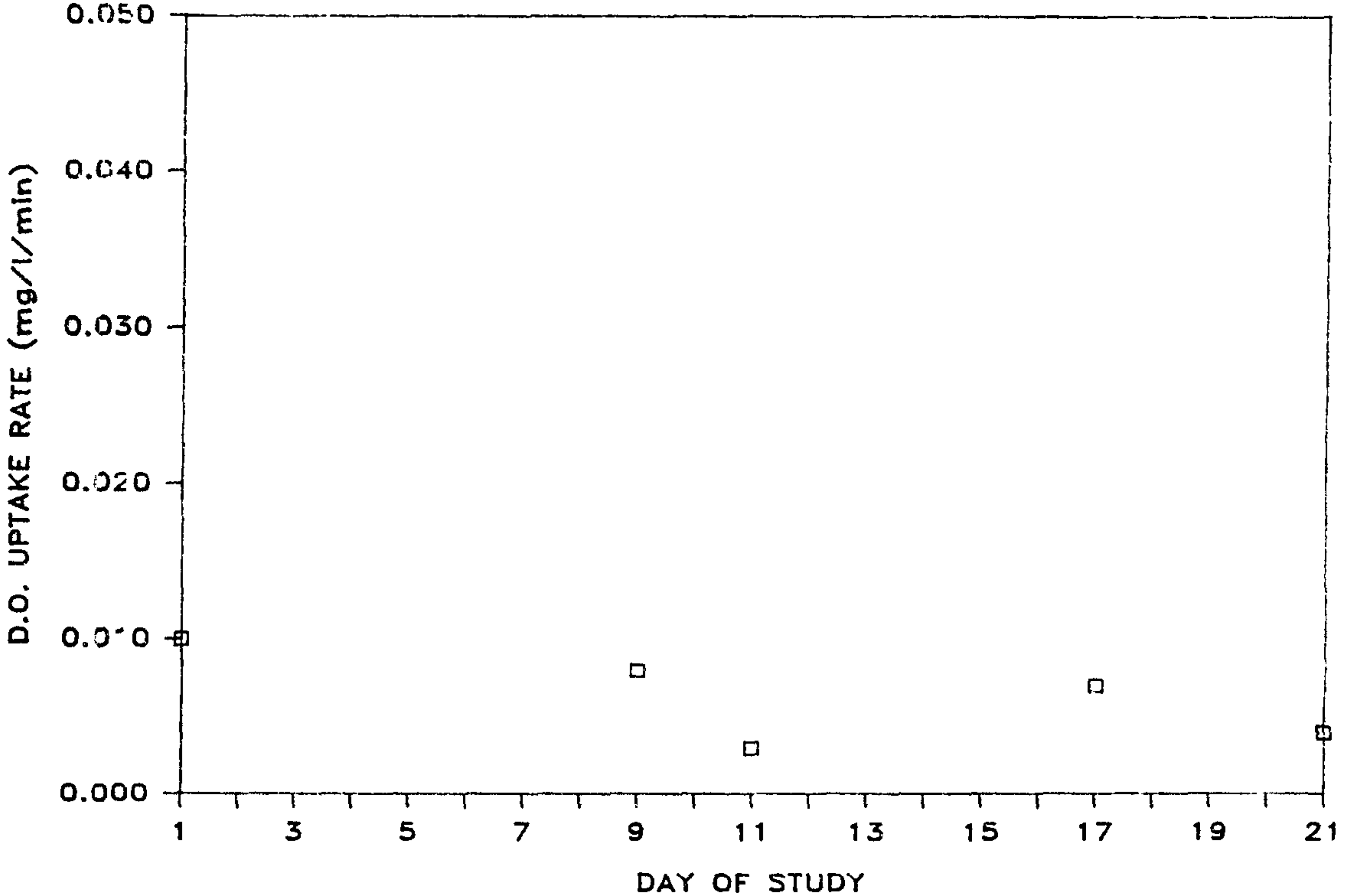
2-7

B-12

ACUTE TOXICITY TEST

DISSOLVED OXYGEN UPTAKE RATES



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HOUSTON, TEXAS

12/28/87 | W.O. NO. 9112A01

FIGURE 2-1
DISSOLVED OXYGEN UPTAKE RATE - ACUTE TOXICITY TEST
BIOLOGICAL TREATMENT STUDY
SHERIDAN DISPOSAL SERVICES

011104

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TABLE 2-4

BIOTREATMENT REACTOR DATA

REACTOR NO 1100 - POND WATER ONLY

PARAMETER	DAY OF STUDY 0	7	14	28	42	49	63	77
TSS (ppm)	353	138	132	152	3100		410	410
VSS (ppm)	278	100	73	80	160		175	170
CHLORIDE (ppm)	341			389				438
SULFATE (ppm)	19			32				82
BOD5 (ppm)	23	32	32	11	54			3
TOC (ppm)	380	560	420	320	290		367	380
OIL & GREASE (ppm)	26	27	18	14	49		16	2
HSL ORGANICS - VOLATILES (ppb)								
(Typical) ACETONE	75				25*			
2-BUTANONE	5				25*			
4-METHYL-2-PENTANONE	17				10*			
TOLUENE	5*				5*			
1,1,1-TRICHLOROETHANE	8 3				5*			
TOTAL XYLENES	8 2				5*			
HSL ORGANICS - SEMIVOLATILES (ppb) (a)								
2,4-DIMETHYLPHENOL	20*		10*	50*	10*			
2-METHYLPHENOL	20*				10*			
4-METHYLPHENOL	20*				10*			
PHENOL	20*		10*	50*	10*			
NAPHTHALENE	20*		10*	50*	10*			
2-METHYLNAPHTHALENE	20*		5*	50*	10*			
POLYCHLORINATED BIPHENYLS (ppb) (a)								
1016	3 2*		3 2*	25*	5*			
1242	3 2*		3 2*	25*	5*			
1260	25*		25*	25*	1 8			

NOTES.

(a) For some reactors the concentration of PCBs in the mixed liquor increased with time. This is due to increasing amounts of sludge tar balls in suspension as the study progressed

* Reported concentration is method detection limit for sample

011105

TABLE 2-4 (Continued)

BIOTREATMENT REACTOR DATA

REACTOR NO 1200 - 1/2 PERCENT SLUDGE SOLIDS

PARAMETER	DAY OF STUDY 0	7	14	28	42	49	63	77
TSS (ppm)	937	654	990	2030	2850		3090	4580
VSS (ppm)	574	480	700	1430	1950		2190	3090
CHLORIDE (ppm)	299			442				392
SULFATE (ppm)	24			73				137
BOD5 (ppm)	150	240	100	98	120			6
TOC (ppm)	530	620	600	510	500		568	720
OIL & GREASE (ppm)	149	465	60	37	204		47	5
HSL ORGANICS - VOLATILES (ppb)								
ACETONE	250*				25*			
2-BUTANONE	870				25*			
4-METHYL-2-PENTANONE	440				10*			
TOLUENE	78				5*			
1,1,1-TRI-CHLOROETHANE	50*				5*			
TOTAL XYLENES	97				5*			
HSL ORGANICS - SEMIVOLATILES (ppb) (a)								
2,4-DIMETHYL-PHENOL	990		100*	500*	60*			
2-METHYLPHENOL	830				60*			
4-METHYLPHENOL	140				60*			
PHENOL	4500		100*	500*	60*			
NAPHTHALENE	120*		100*	500*	60*			
2-METHYL-NAPHTHALENE	120*		50*	500*	60*			
POLYCHLORINATED BIPHENYLS (ppb) (a)								
1016	0.65*		3.2*	100*	40			
1232	11		3.2*	100*	25*			
1242	0.65*		40	100*	25*			
1260	17		120	100*	380			

NOTES

(a) For some reactors the concentration of PCBs in the mixed liquor increased with time. This is due to increasing amounts of sludge tar balls in suspension as the study progressed

* Reported concentration is method detection limit for sample

011106

TABLE 2-4 (Continued)

BIOTREATMENT REACTOR DATA

REACTOR NO 1300 - 1 PERCENT SLUDGE SOLIDS

DAY OF STUDY

PARAMETER	0	7	14	28	42	49	63	77
TSS (ppm)	1520	416	1090	9550	3570		3380	4680
VSS (ppm)	916	350	810	7620	2570		2270	2640
CHLORIDE (ppm)	499			433				459
SULFATE (ppm)	27			124				246
BOD5 (ppm)	360	440	280	300	510			16
TOC (ppm)	770	800	630	670	280		644	1100
OIL & GREASE (ppm)	818	367	115	82	83		107	560
HSL ORGANICS - VOLATILES (ppb)								
ACETONE	780				25*			
BENZENE	160				5*			
2-BUTANONE	2000				25*			
ETHYL BENZENE	100				5*			
2-HEXANONE	150				10*			
4-METHYL-2-PENTANONE	1400				10*			
STYRENE	100				5*			
1,1,1-TRI-CHLOROETHANE	50*				5*			
TOLUENE	280				5*			
TOTAL XYLENES	380				5*			
HSL ORGANICS - SEMIVOLATILES (ppb) (a)								
2,4-DIMETHYL-PHENOL	1800		100*	500*	40*			
2-METHYLPHENOL	1500				40*			
4-METHYLPHENOL	4100				40*			
PHENOL	8600		100*	500*	40*			
NAPHTHALENE	240*		100*	500*	40*			
2-METHYL-NAPHTHALENE	240*		50*	500*	40*			
POLYCHLORINATED BIPHENYLS (ppb) (a)								
1016	0.65*		0.98*	400*	86			
1232	23		0.9 *	400*	50*			
1242	0.65*		19	400*	50*			
1260	19		32	400*	410			

NOTES

(a) For some reactors the concentration of PCBs in the mixed liquor increased with time. This is due to increasing amounts of sludge tar balls in suspension as the study progressed.

* Reported concentration is method detection limit for sample

011107

TABLE 2-4 (Continued)

BIOTREATMENT REACTOR DATA

REACTOR NO. 1400 - 5 PERCENT SLUDGE SOLIDS

PARAMETER	DAY OF STUDY 0	7	14	28	42	49	63	77
TSS (ppm)	10400	2080	6770	6000	27600		620	2830
VSS (ppm)	6760	1640	5040	5000	21700		380	1030
CHLORIDE (ppm)	517			572				615
SULFATE (ppm)	48			301				709
BOD5 (ppm)	847	810	790	1400	850			81
TOC (ppm)	1800	1800	1500	2100	1500		1620	2400
OIL & GREASE (ppm)	250	67	232	232	217		263	29
HSL ORGANICS - VOLATILES (ppb)								
ACETONE	3300				4100			
BENZENE	1500				15*			
2-BUTANONE	9200				75*			
ETHYL BENZENE	720				15*			
2-HEXANONE	830				30*			
4-METHYL-2-PENTANONE	7100				44			
STYRENE	590				15*			
1,1,1-TRICHLOROETHANE	330*				15*			
TOLUENE	2200				15*			
TOTAL XYLENES	2300				15*			
HSL ORGANICS - SEMIVOLATILES (ppb) (a)								
ISOPHORONE	580				300*			
2,4-DIMETHYLPHENOL	5300		100*	2000*	300*			1000*
2-METHYLPHENOL	5000				300*			
4-METHYLPHENOL	13000				300*			
PHENOL	32000		100*	2000*	300*			1000*
NAPHTHALENE	450*		100*	2000*	300*			1000*
2-METHYLNAPHTHALENE	450*		50*	2000*	300*			1000*
POLYCHLORINATED BIPHENYLS (ppb) (a)								
1016	140*		2.6*	1000*	540			320*
1232	2400		2.6*	1000*	120*			320*
1242	140*		62	1000	120			1500
1260	2300		100	1000*	940			2600

NOTES

(a) For some reactors the concentration of PCBs in the mixed liquor increased with time. This is due to increasing amounts of sludge tar balls in suspension as the study progressed.

* Reported concentration is method detection limit for sample.

TABLE 2-4 (Continued)

BIOTREATMENT REACTOR DATA

REACTOR NO 1500 - 1/2 TO 4.5 PERCENT SLUDGE SOLIDS

DAY OF STUDY

PARAMETER	0	7	14	28	42	49	63	77
TSS (ppm)	577	2780	3990	10500	4780	2350	3600	5610
VSS (ppm)	352	2250	2840	8270	3020	1840	2810	2790
CHLORIDE (ppm)	398			457				649
SULFATE (ppm)	24			316				655
BOD5 (ppm)	206	650	370	2100	1300		2960	142
TOC (ppm)	610	1000	830	1900	1700	900	2450	2500
OIL & GREASE (ppm)	148	44	140	282	325	306	398	23
HSL ORGANICS - VOLATILES (ppb)								
ACETONE	NA				460			25*
BENZENE	NA				10*			5*
2-BUTANONE	NA				50*			25*
ETHYL BENZENE	NA				0*			5*
2-HEXANONE	NA				20*			10*
4-METHYL-2-PENTANONE	NA				29			10*
STYRENE	NA				10*			5*
1,1,1-TRICHLOROETHANE	NA				10*			5*
TOLUENE	NA				10*			5*
TOTAL XYLENES	NA				10*			5*
HSL ORGANICS - SEMIVOLATILES (ppb) (a)								
2,4-DIMETHYLPHENOL	NA		210*	5900	300*			500*
2-METHYLPHENOL	NA				300*			500*
4-METHYLPHENOL	NA				300*			500*
PHENOL	NA		210*	14000	300*			500*
NAPHTHALENE	NA		220	4000*	300*			500*
2-METHYLNAPHTHALENE	NA		340	4000*	300*			500*
POLYCHLORINATED BIPHENYLS (ppb) (a)								
1016	0.65*		26*	1000*	510			550*
1232	10		26*	1000*	120*			550*
1242	0.65*		160	1000*	120*			550*
1260	7.2		830	1000*	1300			3700

NOTES

(a) For some reactors the concentration of PCBs in the mixed liquor increased with time. This is due to increasing amounts of sludge tar balls in suspension as the study progressed

* Reported concentration is method detection limit for sample

NA Not analyzed

011109

TABLE 2-4 (Continued)

BIOTREATMENT REACTOR DATA

REACTOR NO 1600 - 1/2 PERCENT POND SLUDGE AEROBIC/ANOXIC CYCLING

DAY OF STUDY

PARAMETER	0	7	14	28	42	49	63	77
TSS (ppm)	697	565	7160	3080	3450		2680	4730
VSS (ppm)	448	490	5530	2130	2440		1950	2600
CHLORIDE (ppm)	342			441				437
SULFATE (ppm)	22			89				246
BOD5 (ppm)	382	270	230	700	510			87
TOC (ppm)	680	800	780	760	560		713	1500
OIL & GREASE (ppm)	138	45	124	134	249		118	13
HSL ORGANICS - VOLATILES (ppb)								
ACETONE	840				100			
BENZENE	100				5*			
2-BUTANONE	2000				25*			
ETHYL BENZENE	55				23			
2-HEXANONE	120				10*			
4-METHYL-2-PENTANONE	990				13			
STYRENE	56				19			
1,1,1-TRICHLOROETHANE	50*				5*			
TOLUENE	160				32			
TOTAL XYLENES	200				70			
HSL ORGANICS - SEMIVOLATILES (ppb) (a)								
2,4-DIMETHYLPHENOL	1300		100*	2000*	310			500*
2-METHYLPHENOL	850				150			
4-METHYLPHENOL	2800				190			
PHENOL	6300		100*	2000*	140			500*
NAPHTHALENE	120*		200	2000*	100*			500*
2-METHYLNAPHTHALENE	120*		200	2000*	100*			500*
POLYCHLORINATED BIPHENYLS (ppb) (a)								
1016	0.65*		52*	1000*	310			32*
1232	19		52*	1000*	100*			32*
1242	0.65*		570	1000*	100*			34
1248	0.65*		52*	1000*	100*			340
1260	13		1000	1000*	760			1100

NOTES

(a) For some reactors the concentration of PCBs in the mixed liquor increased with time. This is due to increasing amounts of sludge tar balls in suspension as the study progressed.

* Reported concentration is method detection limit for sample

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detection limits by day 42. Note that detection limits for several compounds varied between sampling days and generally increased with time. For reactor 1400, all volatile and semi-volatile constituents were reduced to below detection limits by day 42 except acetone and 4-methyl-2-pentanone. Both are known to be readily biodegradable, and the latter had, at that point, been reduced by over 93%. Acetone could have been present at increased concentrations due to formation as a degradation by-product. Reactor 1500 had the same two compounds present at day 42 but by day 77 they had been reduced to below detection limits.

A phase separation occurred in the reactors and a heavy tar-like residue was formed and began accumulating on the bottoms of the reactors. This phenomenon was first observed in reactors 1400 and 1500 on day 28.

This residue was sampled on day 42 from reactor 1400 and on day 77 from reactors 1400 and 1500. The tar-like residue was analyzed for the HSL organics on both occasions. Results of these analyses are compared with raw sludge data in Table 2-5. For all three samples the levels of volatile and semi-volatile HSL constituents were below sample detection limits. The detection limits for semi-volatiles were relatively high, ranging from 140 to 350 ppm.

A mass balance was conducted for reactor 1400 and the results are summarized in Table 2-6 and the detailed analysis is presented in Table 2-7. For volatile organic compounds the data indicates substantially complete removal, 98%. For the semi-volatile compounds, the data is less definitive due to high detection levels in the residue. It is apparent, however, that significant reductions in semi-volatile compound concentrations did occur, 81% or more, in Reactor 1400.

PCBs were detected in the residue at concentrations above those that had been detected in the raw sludge sample. The raw sludge had been spiked to approximately 100 ppm Arochor 1260 to assure that there would be sufficient amount present to demonstrate biodegradation if it occurred. The concentrations of PCBs in the residue from reactor 1400 on day 42 were approximately double those which had been detected (and estimated) in the raw spiked sludge. Since the volume of the residue was approximately one-half of the original sludge volume added to each reactor, the PCBs were apparently concentrated in the residue. By day 77, however, reactor 1400 residue PCB concentrations did appear to be reduced somewhat, particularly if Aroclors 1232 and 1242 are assumed not to be present.

TABLE 2-5

COMPARISON BETWEEN RAW SLUDGE AND REACTOR RESIDUES

DETECTED PARAMETERS	RAW SLUDGE CONCENTRATION (ppm)	REACTOR 1400 DAY 42 RESIDUE CONCEN-TRATIONS (ppm) (a)	REACTOR 1400 DAY 77 RESIDUE CONCEN-TRATIONS (ppm) (a)		REACTOR 1500 DAY 77 RESIDUE CONCEN-TRATIONS (ppm) (a)
HSL ORGANICS - VOLATILES					
BENZENE	170	<0.5	<0.5		<0.5
ETHYL BENZENE	580	<0.5	<0.5		<0.5
STYRENE	340	<0.5	<0.5		<0.5
TETRACHLOROETHENE	51	<0.5	<0.5		<0.5
TOLUENE	700	<0.5	<0.5		<0.5
TOTAL XYLENES	1600	<0.5	<0.5		<0.5
HSL ORGANICS - SEMIVOLATILES (b)					
2-METHYLNAPHTHALENE	220	<300	<140		<350
NAPHTHALENE	270	<300	<140		<350
N-NITROSODIPHENYLAMINE	190	<300	<140		<350
2,4-DIMETHYLPHENOL	460	<300	<140		<350
2-METHYLPHENOL	340	<300	<140		<350
4-METHYLPHENOL	850	<300	<140		<350
PHENOL	1500	<300	<140		<350
HSL ORGANICS - PESTICIDES/PCBS					
ARCHLOR-1016	55	100	<40		<40
ARCHLOR-1260	13 (100)(c)	140	150		240
CONGENER ANALYSIS				% REDUCTION (DAY 42 to 77	
MONOCHLOROBIPHENYL	ND	ND	8.1		
DICHLOROBIPHENYLS	8.4	70	12	83	
TRICHLOROBIPHENYLS	9.8	120	15	88	
TETRACHLOROBIPHENYLS	13	120	11	91	
PENTACHLOROBIPHENYLS	3.8	88	28	68	
HEXACHLOROBIPHENYLS	1.7	200	59	71	
HEPTACHLOROBIPHENYLS	ND	110	14	87	
OCTACHLOROBIPHENYLS	ND	6.6	6.6	0	
NONACHLOROBIPHENYLS	ND	ND	ND		
DECACHLOROBIPHENYL	ND	ND	ND		
TOTAL	37	[illegible]	154		

NOTES

(a) The residue represents approximately 50% of the mass of the original sludge with no degradation, and 100% concentration of constituents in the residue, the residue concentrations would be approximately double those of the sludge.

(b) Bis(2-Ethylhexyl)phthalate was detected in the residues but not in the raw sludge. It is believed to be a laboratory contaminant resulting from the use of plastic reactors.

(c) The sludge added to the reactors was spiked with Archlor 1260 to a total concentration of approximately 100 ppm

D237

Table 2-6

MASS BALANCE SUMMARY - REACTOR 1400 - 5 PERCENT SLUDGE SOLIDS
PHASE I BIOLOGICAL TREATMENT STUDY

SHERIDAN DISPOSAL SITE

PARAMETER	TIME ZERO TOTAL MASS [a] (grams)	DAY 42 TOTAL MASS [b] (grams)	DAY 77 TOTAL MASS [b] (grams)	DAY 77 PERCENT MASS REMOVED
WATER MASS	63300	63300	63300	0
SLUDGE MASS (wet weight)	7150	4352	3560	50
SLUDGE MASS (dry weight)	3465	3803	3154	9
OIL & GREASE	2439	1972	2089	14
TOTAL DETECTED VOLATILES	28 99	0 68	0 54	98
TOTAL DETECTED SEMIVOLOATILES	26.96	7 69	5 02	81
TOTAL DETECTED PCBS [c]	1 20	[illegible]	[illegible]	[illegible]

NOTES

[a] The time zero mass was calculated for data on pond water an untreated sludge (with estimated 100 ppm spike of Aroclor 1260) Volatile, semivolatile and PCB data were not available for pond water and were assumed to be zero (this is a conservative assumption resulting in the lowest overall removal efficiencies)

[b] Total mass in reactor plus mass removed during sampling For sludge mass the masses of total suspended solids in the reactor and of residue were included in the calculation

[c] Aroclor 1260 was added to the sludge before its addition to the reactors at a target concentration of 100 ppm in the sludge

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TABLE 2-7

MASS BALANCE FOR REACTOR 1450 - 5 PERCENT SLUDGE SOLIDS
PHASE I BIOLOGICAL TREATMENT STUDY
SHERIDAN DISPOSAL SITE

PARAMETER	TIME ZERO (a) WATER CONC (as noted)	TIME ZERO (a) WATER MASS (grams)	TIME ZERO (a) SLUDGE CONC (as noted)	TIME ZERO (a) SLUDGE MASS (grams)	TIME ZERO (a) TOTAL MASS (grams)	MASS REMOVED DURING SAMPLING (b) (DAY 0-42) (grams)	DAY 42 WATER CONC (as noted)	DAY 42 WATER MASS (grams)	DAY 42 SLUDGE CONC (as noted)	DAY 42 SLUDGE MASS (grams)	DAY 42 TOTAL MASS (c) (grams)	MASS REMOVED DURING SAMPLING (b) (DAY 43-77) (grams)	DAY 77 WATER CONC (as noted)	DAY 77 WATER MASS (grams)	DAY 77 SLUDGE CONC (as noted)	DAY 77 SLUDGE MASS (grams)	DAY 77 TOTAL MASS (c) (grams)	PERCENT MASS REMOVAL
WATER MASS		63100				11000		12100			63100	11000		53300			61100	3
SLUDGE MASS (WET)				7150	7150	600				7600	4820 (c)	600				2500	3686 (c)	48
SLUDGE MASS (DRY)	70	4	484000	3461	3465	840	27600	491	749000	2051 (d)	1601	496	2630	60	785000	1716	3154	9
OIL & GREASE	17	1	341000	2414	2415	176	117	7	612000	1591	1971	168	25	1	613000	1346	2059	14
HSL ORGANICS - VOLATILES (ppb)																		
ACETONE	6	0.00	270000 *	1.57	1.57	0.11	4100	0.13	2100 *	0.01	0.26	00	NA	0.00	2500 *	0.01	0.12	92
BENZENE	6	0.00	170000	1.22	1.22	0.02	15 *	00	500 *	00	0.01	00	NA	0.00	500 *	00	0.02	98
2-BUTANONE	6	0.00	270000 *	1.57	1.57	0.15	75 *	00	2500	0.01	0.15	00	NA	0.00	2500 *	0.01	0.15	90
ETHYL BENZENE	6	0.00	580000	4.15	4.15	0.01	15 *	00	500 *	00	0.01	00	NA	0.00	500 *	00	0.01	100
2-HEXANONE	6	0.00	90000 *	0.64	0.64	0.01	30 *	00	1000 *	00	0.07	00	NA	0.00	1000 *	00	0.02	9
4-METHYL-2-PENTANONE	6	0.00	90000 *	0.64	0.64	0.11	44	00	1000 *	00	0.12	00	NA	0.00	1000 *	00	0.11	8
STYRENE	6	0.00	340000	2.43	2.43	0.01	15 *	00	500 *	00	0.01	00	NA	0.00	500 *	00	0.01	100
1,1,1-TRI-CHLOROETHANE	6	0.00	45000 *	0.32	0.32	0.01	15 *	00	500 *	00	0.01	00	NA	0.00	500 *	00	0.01	96
TOLUENE	6	0.00	700000	5.01	5.01	0.03	15 *	00	500 *	00	0.04	00	NA	0.00	500 *	00	0.04	99
TOTAL XYLENES	6	0.00	1600000	11.44	11.44	0.04	15 *	01	500 *	00	0.04	00	NA	0.00	501 *	00	0.04	100
TOTAL VOLATILES		0		28.99	28.99	0.51		0.14		0.01	0.68	0.01	NA	0.00		0.02	0.54	98
HSL ORGANICS - SEMIVOLATILES (ppb)																		
ISOPHORONE	6	0.00	130000 *	0.93	0.93	0.19	300 *	0.01	300000 *	0.74	0.94	0.08	NA	0.00	140000 *	0.31	0.56	[illegible]
2,4-DIMETHYL-PHENOL	6	0.00	460000	3.29	3.29	0.27	300 *	0.01	300000 *	0.76	1.06	0.09	1000 *	0.02	140000 *	0.31	0.68	79
2-METHYLPHENOL	6	0.00	340000	2.43	2.43	0.26	300 *	0.01	300000 *	0.76	1.05	0.06	NA	0.00	140000 *	0.31	0.65	73
4-METHYLPHENOL	6	0.00	850000	6.08	6.08	0.35	300 *	0.01	300000 *	0.76	1.16	0.06	NA	0.00	140000 *	0.31	0.76	87
PHENOL	6	0.00	1500000	10.73	10.73	0.68	300 *	0.01	300000 *	0.76	1.47	0.09	1000 *	0.02	140000 *	0.31	1.10	90
NAPHTHALENE	6	0.00	270000	1.93	1.93	0.18	300 *	0.01	300000 *	0.76	0.97	0.09	1000 *	0.02	140000 *	0.31	0.61	69
2-METHYL-NAPHTHALENE	6	0.00	220000	1.57	1.57	0.16	300 *	0.01	300000 *	0.76	0.97	0.09	1000 *	0.02	140000 *	0.31	0.61	61
TOTAL SEMIVOLATILES		0.00		26.96	26.96	2.16		0.03		5.46	7.69	0.62		0.09		2.16	5.02	81
POLYCHLORINATED BIPHENYLS (ppb)																		
1016	6	0.00	55000	0.39	0.39	0.07	540	0.03	100000	0.76	0.35	0.01	320 *	0.01	40000 *	0.09	0.19	51
1232	6	0.00	6400 *	0.05	0.05	0.00	120 *	00	12000 *	0.08	0.15	0.03	320 *	0.01	40000 *	0.09	0.18	-291 (f)
1242	6	0.00	6400 *	0.05	0.05	0.02	120	00	2000 *	0.08	0.11	0.04	1500	0.01	40000 *	0.09	0.15	-19 (f)
1260	6	0.00	100000 (e)	0.72	0.72	0.15	550	0.03	160000	0.36	0.55	0.11	2500	0.06	150000	0.31	0.43	[illegible]
TOTAL AROCLORS		0.00		1.20	1.20	0.24		0.06		0.79	1.13	0.20		0.10		0.59	1.16	7

NOTES

(a) The time zero mass was calculated for data on pond water and untreated sludge (with estimated 100 ppm spike of Aroclor 1260). Volatile, semivolatile and PCB data were not available for pond water and were assumed to be zero (a conservative assumption).

(b) Based on average water concentrations for all analyzed samples and total water sample volume removed, plus 400 grams of sludge residue for Day 42 and Day 77 events only. The residue mass was estimated based on an estimated sample volume of 500 ml and an estimated residue specific gravity of 1.2.

(c) Total mass in reactor plus mass removed during sampling. The sludge mass was calculated by summing the total suspended solids in the reactor plus the total suspended solids in the water samples removed, dividing that sum by the percent solids in the residue and adding that mass to the mass of residue in the reactor plus the mass of residue removed during sampling.

(d) Sludge mass used in calculating these masses were based on measured volumes in the reactor of 2.2 liters on Day 42 and 1.9 liters on Day 77 and on an assumed specific gravity of 1.2.

(e) Aroclor 1260 was added to the sludge before its addition to the reactors at a target concentration of 100 ppm in the sludge.

(f) Negative percent removals are likely an artifact of large increases in the detection limits between time zero samples and subsequent sludge residue samples.

* The reported concentration value is the method detection limit for the sample.

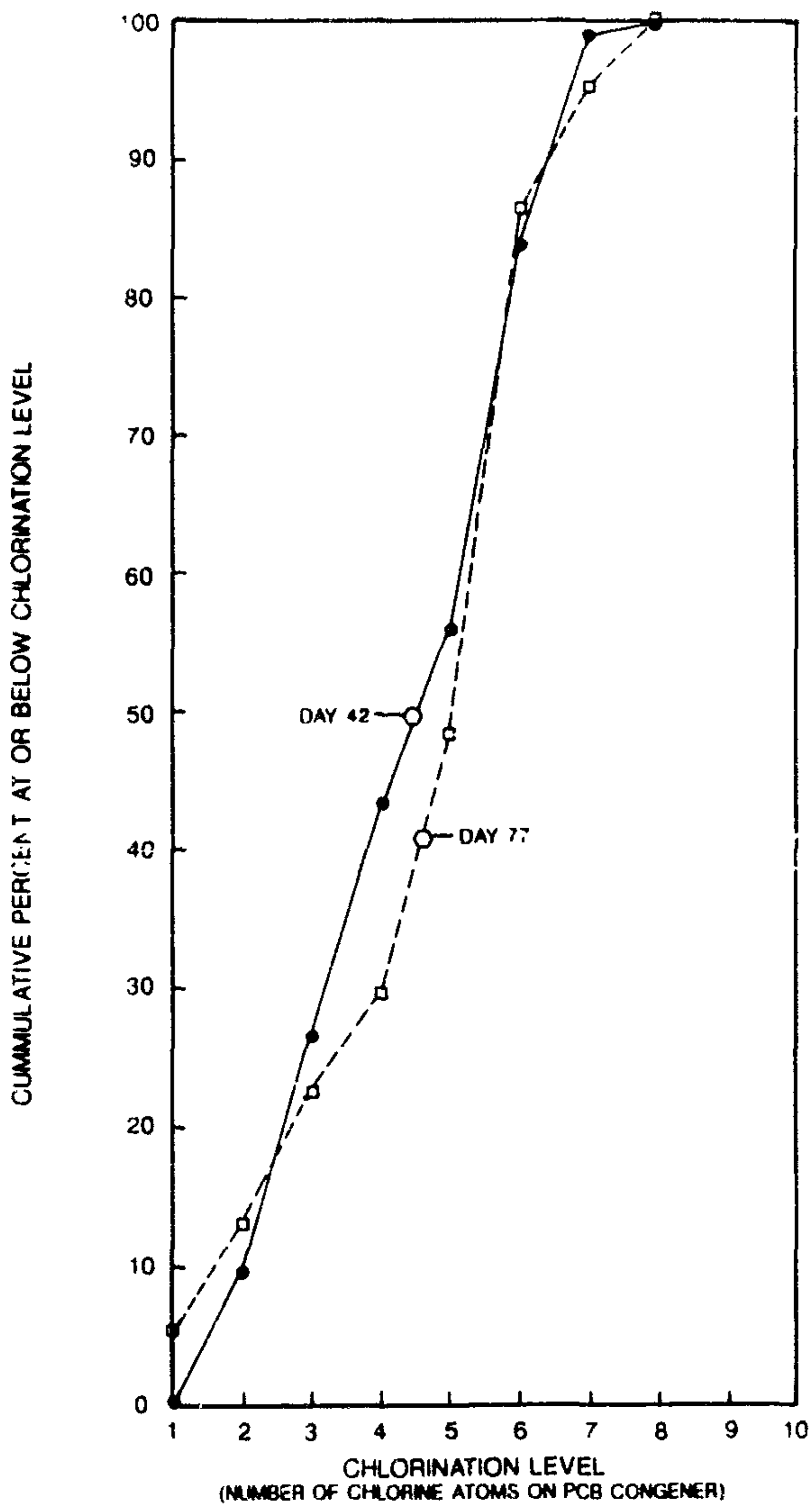
011114

The mass balance for Reactor 1400 (Table 2-7) showed an overall 2 percent decrease in the mass of PCB's. This mass balance, however, was conservative because it assumed that the concentration of non detected Aroclors 1232 and 1242 were equal to their detection limits in the day 77 samples. This resulted in a negative percent removal for these two Aroclors, because of increases in the detection limits for the sludge samples. If it is assumed that the mass of these two Aroclors does not change from that originally measured in the reactors (also a conservative assumption) the total reduction in PCB mass in Reactor 1400 in 77 days is calculated to be 23 percent.

The residue is a hydrophobic material which is semi-solid in nature. It and the PCBs contained in it appear to be in a relatively immobile state. Although biotreatment did not clearly remove all the semi-volatile compounds and PCBs it apparently did render them less mobile by concentrating them in the residue.

Two analytical methods were used in measuring the PCBs. The Aroclor analysis, (Method 8080) is a GC-PID method which is the approach specified in the EPA Contract Laboratory Program. The congener analysis was used because the Aroclor analysis, while it is the accepted method for PCB quantification has some shortcomings with regards to assessing biodegradation. Aroclors are madeup of mixtures of congeners. Different congeners have different degrees of biodegradability. As degradation proceeds it can alter or destroy the patterns by which the individual Aroclors are identified. The GC-MS congener analysis enables an analysis of chlorination level distributions within a sample. Since lower chlorination level PCBs are typically the most readily biodegraded, a shift in the congener distribution between samples can indicate biodegradation. The GC-MS method, however, has not been refined to a point that it offers reliable quantification for PCB sludges. Figure 2-2 illustrates the congener distributions based on the Method 680 results for residue samples taken from Reactor 1400 on days 42 and 77. Notice that for congeners with five chlorine atoms or fewer the cumulative percentage present is significantly less in the day 77 sample than in the day 42 sample. This trend is even more significant for congeners with four chlorines or fewer. Such a change in congener distribution is a good indication that biodegradation has occurred. The conclusions based on these data should be considered tentative due to the state of development of the GC/MS PCB analysis. Since only two data sets are available, statistical comparison of the data is not possible.

0111115



011116

ERM-Southwest, Inc.
HOUSTON, TEXAS

FIGURE 2- 2
SSC-PHASE I-BIOTREATMENT
CONGENER DISTRIBUTION
REACTOR 1400
BIOLOGICAL TREATMENT STUDY
SHERIDAN DISPOSAL SERVICES

5/19/88	W.O. NO.	9112A08

3.1 Preliminary Design Concepts

The use of biological treatment to reduce the mobility, toxicity, or volume of wastes may be a technically feasible option. The data acquired to date, however, are not sufficient to design a specific biological treatment system at the SDS site. To assess the general design implications of using biological treatment, a preliminary basis for design is provided below:

Sludge:water ratio	=	1:9
Seed material	-	native microorganisms
Sludge volume reduction	=	50%
Treatment period required	=	90 days
Aeration energy required	=	0.75 horsepower/1000 cubic feet (100 HP/MG)

Periodic resuspension of residue by cutter-head dredge, or other means, may be required.

Nutrient requirements:

Nitrogen	100 lbs/10^6 lbs of sludge
Phosphorous	20 lbs/10^6 lbs of sludge

pH Control:

Acid addition	20 lbs/10^6 lbs of sludge
Base addition	20 lbs/10^6 lbs of sludge

Because the treatment residue is hydrophobic it appears to be readily dewatered. For final disposal the residue could be stabilized or bulked with soil at an approximate ratio of 2:1 (soil:sludge), although testing of different bulking ratios is needed for final design.

3.2 Options for Further Testing

The most logical next step for testing is to conduct a second round of laboratory studies in which only one loading rate is studied (1:9 sludge to water). More analysis of the sludge and residue at the beginning and end of the study should be obtained to provide a strong statistical basis for drawing conclusions about the ultimate degree of HSL organics and PCB removal efficiencies. During this study, other sources of micro-organisms should be tested for their ability to degrade PCBs and/or reduce the volume of residue produced. Also during this study the phase separation phenomenon should be studied to determine when it occurs and identify opportunities to optimize the system.

4 - CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

1. The biodegradation process (including volatilization) effectively reduced concentrations of all volatile HSL organic constituents detected in the sludge by 98% in the most heavily loaded reactor.

2. The biodegradation process reduced semi-volatile HSL organic constituents by 81% or more in the most heavily loaded reactor.

3. PCB removal was not clearly demonstrated. However, limited data does indicate that some PCB degradation did occur.

4. The biodegradation process reduced the volume of sludge to approximately half of its original volume. The resulting residue is a tar-like substance with a specific gravity of 1.2. Based on visual observation the material is easily dewatered as it forms discrete hydrophobic balls. The moisture content of the residue from day 77 samples was between 14.9 and 18.1 percent. On a dry solids basis, the mass reduction achieved is minimal.

5. The highest loading rate used, 5% sludge solids, did not result in apparent toxic effects in the reactor.

6. Aerobic/anoxic cycling does not appear to offer significant benefits over simple aerobic treatment.

7. Stepwise sludge additions do not appear to result in significant advantages over a single sludge addition.

4.2 Recommendations

1. Conduct additional biological treatment studies to better define the extent of PCB degradation achievable and the degree of sludge volume reduction attainable.

ATTACHMENT A

Laboratory Results

011119

Laboratory Analytical Reports
Biodegradation Treatment Testing

FIELD NO.		MATRIX	CLASS	SOURCE			DATE	COLLECTOR	LAB NO.
The following samples were generated and tested to review aqueous biological treatment									
SDS-INOCN-		SLUDGE	COMPOS	[illegible] Sludge [illegible] sample			22-Jun-87	Birdwell	53942 - 2
SDS-BIO-	1000	WATER	GRAB	Raw Impoundment water			16-Jun-87	Birdwell	53942 - 1
SDS-BIO-	1001	WATER	GRAB	SDS-BIO-1000 subsample			22-Jun-87	Birdwell	54003 - 1
SDS-BIO-	1002	WATER	GRAB	Tox. Reactor		Day -8	06-Jul-87	Birdwell	54029 - 1
SDS-BIO-	[illegible]	WATER	GRAB	Tox. Reactor		Day -1	13-Jul-87	Birdwell	[illegible]
SDS-BIO-	1100	WATER	GRAB	Reactor	1	Day 0	14-Jul-87	Birdwell	54072 - 1
SDS-BIO-	1200	WATER	GRAB	Reactor	2	Day 0	14-Jul-87	Birdwell	54072 - 2
SDS-BIO-	1300	WATER	GRAB	Reactor	3	Day 0	14-Jul-87	Birdwell	54072 - 3
SDS-BIO-	1400	WATER	GRAB	Reactor	4	Day 0	14-Jul-87	Birdwell	54072 - 4
SDS-BIO-	1500	WATER	GRAB	Reactor	5	Day 0	14-Jul-87	Birdwell	54072 - 5
SDS-BIO-	1600	WATER	GRAB	Reactor	6	Day 0	14-Jul-87	Birdwell	54072 - 6
SDS-BIO-	[illegible]	WATER	GRAB	Reactor	1	Day 0	28-Jul-87	Birdwell	54169 - 7
SDS-BIO-	1210	WATER	GRAB	Reactor	2	Day 0	28-Jul-87	Birdwell	54169 - 8
SDS-BIO-	1310	WATER	GRAB	Reactor	3	Day 0	28-Jul-87	Birdwell	54169 - 9
SDS-BIO-	1400	WATER	GRAB	Reactor	4	Day 0	28-Jul-87	Birdwell	54169 -10
SDS-BIO-	1500	WATER	GRAB	Reactor	5	Day 0	28-Jul-87	Birdwell	54169 -11
SDS-BIO-	1107	WATER	GRAB	Reactor	1	Day 7	21-Jul-87	Clarke	54126 - 1
SDS-BIO-	1207	WATER	GRAB	Reactor	2	Day 7	21-Jul-87	Clarke	54126 - 2
SDS-BIO-	1307	WATER	GRAB	Reactor	3	Day 7	21-Jul-87	Clarke	54126 - 3
SDS-BIO-	1407	WATER	GRAB	Reactor	4	Day 7	21-Jul-87	Clarke	54126 - 4
SDS-BIO-	1507	WATER	GRAB	Reactor	5	Day 7	21-Jul-87	Clarke	54126 - 5
SDS-BIO-	1607	WATER	GRAB	Reactor	6	Day 7	21-Jul-87	Clarke	54126 - 6
SDS-BIO-	1114	WATER	GRAB	Reactor	1	Day 14	28-Jul-87	Birdwell	54169 - 1
SDS-BIO-	1214	WATER	GRAB	Reactor	2	Day 14	28-Jul-87	Birdwell	54169 - 2
SDS-BIO-	1314	WATER	GRAB	Reactor	3	Day 14	28-Jul-87	Birdwell	54169 - 3
SDS-BIO-	1414	WATER	GRAB	Reactor	4	Day 14	28-Jul-87	Birdwell	54169 - 4
SDS-BIO-	1514	WATER	GRAB	Reactor	5	Day 14	28-Jul-87	Birdwell	54169 - 5
SDS-BIO-	1614	WATER	GRAB	Reactor	6	Day 14	28-Jul-87	Birdwell	54169 - 6
SDS-BIO-	1128	WATER	GRAB	Reactor	1	Day 28	11-Aug-87	Birdwell	54291 - 1
SDS-BIO-	1228	WATER	GRAB	Reactor	2	Day 28	11-Aug-87	Birdwell	54291 - 2
SDS-BIO-	1328	WATER	GRAB	Reactor	3	Day 28	11-Aug-87	Birdwell	54291 - 3
SDS-BIO-	1428	WATER	GRAB	Reactor	4	Day 28	11-Aug-87	Birdwell	54291 - 4
SDS-BIO-	1528	WATER	GRAB	Reactor	5	Day 28	11-Aug-87	Birdwell	54291 - 5
SDS-BIO-	1628	WATER	GRAB	Reactor	6	Day 28	11-Aug-87	Birdwell	54291 - 6
SDS-BIO-	0042	WATER	GRAB	Trip Blank			25-Aug-87	Clarke	54388 - 7
SDS-BIO-	1142	WATER	GRAB	Reactor	1	Day 42	25-Aug-87	Clarke	54388 - 1
SDS-BIO-	1242	WATER	GRAB	Reactor	2	Day 42	25-Aug-87	Clarke	54388 - 2
SDS-BIO-	1342	WATER	GRAB	Reactor	3	Day 42	25-Aug-87	Clarke	54388 - 3
SDS-BIO-	1442	WATER	GRAB	Reactor	4	Day 42	25-Aug-87	Clarke	54388 - 4
SDS-BIO-	1542	WATER	GRAB	Reactor	5	Day 42	25-Aug-87	Clarke	54388 - 5
SDS-BIO-	1642	WATER	GRAB	Reactor	6	Day 42	25-Aug-87	Clarke	54388 - 6
SDS-BIO-	1142A	SLUDGE	GRAB	Reactor	[illegible]	Day 42	25-Aug-87	Clarke	54388 - 8
SDS-BIO-	1549	WATER	GRAB	Reactor	5	Day 42	01-Sep-87	Clarke	54459 - 1
SDS-BIO-	1163	WATER	GRAB	Reactor	1	Day 63	15-Sep-87	Clarke	54554 - 1
SDS-BIO-	1263	WATER	GRAB	Reactor	2	Day 63	15-Sep-87	Clarke	54554 - 2
SDS-BIO-	1363	WATER	GRAB	Reactor	3	Day 63	15-Sep-87	Clarke	54554 - 3
SDS-BIO-	1463	WATER	GRAB	Reactor	4	Day 63	15-Sep-87	Clarke	54554 - 4
SDS-BIO-	1563	WATER	GRAB	Reactor	5	Day 63	15-Sep-87	Clarke	54554 - 5

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[illegible]

Laboratory Analytical Reports
Biodegradation Treatment Testing

FIELD NO.		MATRIX	CLASS	SOURCE			DATE	COLLECTOR	LAB NO
SDS-BIO-	[illegible]	WATER	GRAB	Reactor	[illegible]	Day 63	15-Sep-87	Clarke	[illegible]
SDS-BIO-	1077	WATER	GRAB	Reactor	1	Day 77	29-Sep-87	Clarke	[illegible] - 1
SDS-BIO-	1077	WATER	GRAB	Reactor	2	Day 77	29-Sep-87	Clarke	[illegible] - 2
SDS-BIO-	1077	WATER	GRAB	Reactor	3	Day 77	29-Sep-87	Clarke	[illegible] - 3
SDS-BIO-	1077	WATER	GRAB	Reactor	4	Day 77	29-Sep-87	Clarke	[illegible] - 4
SDS-BIO-	1077	WATER	GRAB	Reactor	5	Day 77	29-Sep-87	Clarke	[illegible] - 5
SDS-BIO-	1077	WATER	GRAB	Reactor	6	Day 77	29-Sep-87	Clarke	[illegible] - 6
SDS-BIO-	1077A	SLUDGE	GRAB	Reactor	4	Day 77	29-Sep-87	Clarke	[illegible] - 7
SDS-BIO-	1077A	SLUDGE	GRAB	Reactor	5	Day 63	29-Sep-87	Clarke	[illegible] - 8

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[illegible]

Laboratory Analytical Reports
Biodegradation Treatment Testing

FIELD NO.	GENERAL ANALYSES	ORGANICS AND METALS
The following samples were generated and tested to review aqueous biological treatment		
SDS-BIO-[illegible]	CL, SO4, NH3, TKN, P, K, TOC, O&G, BOD, TSS/VSS	HSL organics, PCB [illegible]
SDS-BIO- [illegible]	CL, SO4, NH3, TKN, P, K, TOC, O&G, BOD, TSS/VSS	
SDS-BIO- [illegible]	TOC, O&G, TSS/VSS	
SDS-BIO- [illegible]	TOC, O&G, TSS/VSS	
SDS-BIO- [illegible]	TOC, O&G, TSS/VSS	
SDS-BIO- [illegible]	CL, SO4, TOC, O&G, BOD, TSS/VSS dewater	PCB 8080
SDS-BIO- [illegible]	CL, SO4, TOC, O&G, BOD, TSS/VSS/dewater	PCB 8080
SDS-BIO- 1306	CL, SO4, TOC, O&G, BOD, TSS/VSS/dewater	PCB 8080
SDS-BIO- [illegible]	CL, SO4, TOC, O&G, BOD, TSS/VSS/dewater	PCB 8080
SDS-BIO- [illegible]	CL, SO4, TOC, O&G, BOD, TSS/VSS/dewater	PCB 8080
SDS-BIO- [illegible]	CL, SO4, TOC, O&G, BOD, TSS/VSS/dewater	PCB 8080
SDS-BIO- [illegible]		HSL organics
SDS-BIO- [illegible]		HSL organics
SDS-BIO- [illegible]		HSL organics
SDS-BIO- [illegible]		HSL organics
SDS-BIO- [illegible]		HSL organics
SDS-BIO- [illegible]	TOC, BOD, O&G, TSS/VSS	
SDS-BIO- [illegible]	TOC, BOD, O&G, TSS/VSS	
SDS-BIO- [illegible]	TOC, BOD, O&G, TSS/VSS	
SDS-BIO- [illegible]	TOC, BOD, O&G, TSS/VSS	
SDS-BIO- 1517	TOC, BOD, O&G, TSS/VSS	
SDS-BIO- [illegible]	TOC, BOD, O&G, TSS/VSS	
SDS-BIO- [illegible]	TOC, O&G, BOD, TSS/VSS/dewater	+ semivol, PCB 8080
SDS-BIO- [illegible]	TOC, O&G, BOD, TSS/VSS/dewater	+ semivol, PCB 8080
SDS-BIO- [illegible]	TOC, O&G, BOD, TSS/VSS/dewater	+ semivol, PCB 8080
SDS-BIO- 1414	TOC, O&G, BOD, TSS/VSS/dewater	+ semivol, PCB 8080
SDS-BIO- [illegible]	TOC, O&G, BOD, TSS/VSS/dewater	+ semivol, PCB 8080
SDS-BIO- [illegible]	TOC, O&G, BOD, TSS/VSS dewater	+ semivol, PCB 8080
SDS-BIO- [illegible]	CL, SO4, TOC, O&G, BOD, TSS/VSS/dewater	+ semivol, PCB 8080
SDS-BIO- [illegible]	CL, SO4, TOC, O&G, BOD, TSS/VSS/dewater	+ semivol, PCB 8080
SDS-BIO- [illegible]	CL, SO4, TOC, O&G, BOD, TSS/VSS/dewater	+ semivol, PCB 8080
SDS-BIO- 1439	CL, SO4, TOC, O&G, BOD, TSS/VSS/dewater	+ semivol, PCB 8080
SDS-BIO- 1539	CL, SO4, TOC, O&G, BOD, TSS/VSS/dewater	+ semivol, PCB 8080
SDS-BIO- [illegible]	CL, SO4, TOC, O&G, BOD, TSS/VSS/dewater	+ semivol, PCB 8080
SDS-BIO- [illegible]	BOD, TOC, NH3, TKN, O&G, VSS/dewater	HSL vol, semivol, test; PCB 8080
SDS-BIO- 1142	BOD, TOC, NH3, TKN, O&G, VSS/dewater	HSL vol, semivol, test; PCB 8080
SDS-BIO- 1242	BOD, TOC, NH3, TKN, O&G, VSS/dewater	HSL vol, semivol, test; PCB 8080
SDS-BIO- 1342	BOD, TOC, NH3, TKN, O&G, VSS/dewater	HSL vol, semivol, test; PCB 8080
SDS-BIO- 1442	BOD, TOC, NH3, TKN, O&G, VSS/dewater	HSL vol, semivol, test; PCB 8080
SDS-BIO- 1542	BOD, TOC, NH3, TKN, O&G, VSS/dewater	HSL vol, semivol, test; PCB 8080
SDS-BIO- [illegible]	BOD, TOC, NH3, TKN, O&G, VSS/dewater	HSL vol, semivol, test; PCB 8080
SDS-BIO- [illegible]		HSL vol, semivol, test; PCB 8080, [illegible]
SDS-BIO- [illegible]	TOC, O&G, TSS/VSS	
SDS-BIO- [illegible]	TOC, O&G, TSS/VSS	
SDS-BIO- [illegible]	TOC, O&G, TSS/VSS	
SDS-BIO- [illegible]	TOC, O&G, TSS/VSS	
SDS-BIO- [illegible]	TOC, O&G, TSS/VSS	
SDS-BIO- [illegible]	TOC, O&G, TSS/VSS, BOD	

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Laboratory Analytical Results
Biodegradation Treatment Testing

FIELD NO.	GENERAL ANALYSES	ORGANICS AND METALS
SDS-BIO- [illegible]	TOC, O&G, TSS/VSS	
SDS-BIO- [illegible]77	CL, SO4,NH3, TKN, P, [illegible], TOC, O&G, BOD, TSS/VSS dewater	
SDS-BIO- [illegible]77	CL, SO4,NH3, TKN, P, K, TOC, O&G, BOD, TSS/VSS/dewater	
SDS-BIO- 1377	CL, SO4,NH3, TKN, P, K, TOC, O&G, BOD, TSS/VSS dewater	
SDS-BIO- 1477	CL, SO4,NH3, TKN, P, K, TOC, O&G, BOD, TSS/VSS/dewater	+ semivol, PCB [illegible]
SDS-BIO- 1577	CL, SO4,NH3, TKN, P, K, TOC, O&G, BOD, TSS/VSS/dewater	HSL organics
SDS-BIO- 1677	CL, SO4,NH3, TKN, P, K, TOC, O&G, BOD, TSS/VSS/dewater	+ semivol, PCB [illegible]
SDS-BIO- 1477A	VOWS	HSL organics, PCB [illegible], PCB [illegible]
SDS-BIO- 1577A	VOWS	HSL organics, PCB [illegible], PCB [illegible]

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APPENDIX C

Phase II Biological Treatability Report
for
Source Control Feasibility Study

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PHASE II
BIOLOGICAL TREATABILITY REPORT
FOR
SOURCE CONTROL FEASIBILITY STUDY

011125

June 8, 1988

W.O. #91-18

Revised August 30, 1988

PHASE II
BIOLOGICAL TREATABILITY REPORT
FOR
SOURCE CONTROL FEASIBILITY STUDY

INTRODUCTION

The Phase I Biological Treatment Study was a preliminary study which yielded data indicating a significant sludge volume reduction could be accomplished via biodegradation, and that reductions in the mass of volatile and semivolatile organic compounds and possibly PCBs could also be achieved. Calculation of the magnitude of these reductions, however, was complicated by the large number of samples which were collected and the manner in which they were collected (i.e., mixed liquor samples as opposed to settled supernatant and solid residue samples). The primary objective of the Phase II study was to better define the magnitude of the reductions in sludge volume, sludge mass, volatile organic compound mass, semivolatile organic compound mass and PCB mass.

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Two additional studies were also conducted during the Phase II study. First, a phase separation study was conducted to establish when the sludge began to settle out to the bottom of the reactors and when it began to form tar balls. This study was based on visual observation made in a six gallon stirred reactor. Second, a study of composting using White Rot Fungus (a lignin degrader) was also conducted using wood chips as a medium. Literature indicated that the specific species of White Rot Fungus tested offered significant potential for PCB degradation. Discussions with a coauthor of much of the literature lead to development of the composting test.

AQUEOUS BIOLOGICAL REACTORS

The test was started on November 20, 1987. The sludge was spiked with Aroclor 1260 and carefully homogenized. Six spiked sludge samples were collected for analysis on day zero. Results for these analyses are reported in Table C-1, as are the averages and standard deviations for those results. The average values are used as the basis of comparison for later samples.

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TABLE C-1

Initial Sludge Analysis
Phase 2 Biodegradation Study

Sheridan Disposal Site - Feasibility Study

PARAMETER	Replicate Sludge Sample Numbers 2001	2002	2003	2004	2005	2006	Average	Standard Deviation
VOLATILES								
Benzene (mg/kg)	230	170	180	200	210	190	196.7	19.7
Ethylbenzene (mg/kg)	890	710	720	810	790	710	771.7	65.9
Styrene (mg/kg)	520	410	420	480	460	420	451.7	39.3
Tetrachloroethene (mg/kg)	93	35	72	43	40	72	59.2	21.2
Toluene (mg/kg)	980	750	770	880	870	790	840.0	79.2
Total xylenes (mg/kg)	2700	2100	2100	2400	2300	2100	2283.3	219.2
SEMIVOLATILES								
bis(2-ethylhexyl)phthalate (mg/kg)	83	60	65	37	39	43	54.5	16.5
Fluoranthene(mg/kg)	42	60	65	37	39	43	47.7	10.8
2-methylnaphthalene (mg/kg)	190	210	190	200	160	190	190.0	15.3
Naphthalene (mg/kg)	260	220	220	200	180	220	216.7	24.3
N-Nitrosodiphenylamine (mg/kg)	230	220	240	210	184	220	217.3	17.6
Phenanthrene (mg/kg)	140	140	65	37	110	130	103.7	39.4
2,4-Dimethylphenol (mg/kg)	370	320	160	260	280	340	288.3	67.9
2-Methylphenol (mg/kg)	260	200	170	150	160	180	186.7	36.4
4-Methylphenol (mg/kg)	710	180	400	420	230	360	383.3	170.2
Phenol (mg/kg)	1000	650	650	600	600	660	693.3	139.2
PCB'S								
Aroclor-1242 (ug/kg)	80000	88000	67000	60000	40000	88000	70500.0	17105.1
Aroclor-1260 (ug/kg) [b]	410000	300000	240000	340000	250000	340000	313333.3	58214.2
Monochlorobiphenyls (ug/kg)	2800	1800	320	250	ND	ND	861.7	1063.8
Dichlorobiphenyls (ug/kg)	7200	6600	11000	4300	3500	850	5575.0	3198.4
Trichlorobiphenyls (ug/kg)	16000	13000	23000	12000	7400	2300	12283.3	6490.6
Tetrachlorobiphenyls (ug/kg)	15000	13000	21000	6300	2900	5200	10566.7	6327.4
Pentachlorobiphenyls (ug/kg)	15000	13000	18000	6900	4800	2900	10100.0	5552.8
Hexachlorobiphenyls (ug/kg)	49000	43000	58000	23000	21000	4000	33000.0	18556.2
Heptachlorobiphenyls (ug/kg)	24000	21000	38000	13000	22000	15000	22166.7	8070.9
Octachlorobiphenyls (ug/kg)	2200	ND	7400	ND	ND	7500	2850.0	3344.5
Nonachlorobiphenyls (ug/kg)	ND [a]	ND	ND	ND	ND	ND	ND	ND
Decachlorobiphenyl (ug/kg)	ND	ND	ND	ND	ND	ND	ND	ND
PHYSICAL CHARACTERISTICS								
Oil (%)	33.6	11.8	46	44.5	41.8	27.1	34.1	11.9
Water (%)	52.9	73.9	40.2	40.9	44.1	61.1	52.2	12.2
Solids (%) [c]	13.5	14.3	13.8	14.6	14.1	11.8	13.7	0.9
Ash @ 550 C (%) (Dry weight basis)	26.8	26.2	26.1	25.3	26.3	27.3	26.3	0.6
Total Solids (%) [c]	43.7	40.5	44.1	47.2	43.8	42.8	43.7	2.0
Specific Gravity (@ 77 F)								

NOTES

[a] Detection limits were not reported for the congener analyses

[b] Aroclor 1260 was added as a spike to the raw sludge to assure a high enough concentration to detect biodegradation should it occur

[c] The difference between solids and total solids is that solids is based on a freon extraction technique which separates oil from the solids. Total solids, however, is based on drying at 104C and the high molecular weight oil, and dissolved solids from the water and oil phases are measured as total solids

C-2

At start-up each of three reactors received 57.2 liters of pond water and 2.14 kg of sludge. Reactor 2100 was seeded with native micro-organisms. Reactor 2200 was seeded with organisms provided by General Electric which have demonstrated ability to degrade PCBs in laboratory studies. Reactor 2300 was seeded with microorganisms provided by Microbe Masters, Inc. which have demonstrated ability to degrade high molecular weight hydrocarbons and other compounds resistant to biodegradation. Otherwise, the reactors were operated in the same manner as during the Phase 1 Study and the same analytical procedures were used.

On day 71 (January 29) water and sludge samples were collected from each reactor for analysis. (EPA observers collected split samples from Reactors 2200 and 2300). Results of analyses of day zero and day 71 samples are presented in Table C-2.

Mass balances were conducted for each reactor and results are summarized in Table C-3. Results indicate that the wet weight of sludge was reduced 40 to 49 percent. On a dry weight basis, however, the mass of sludge was essentially unchanged (.2% to 12.9% reduction). Reductions in the mass of oil and grease ranged from 15 percent to 25 percent. (Could vary slightly due to assumed concentrations of oil and grease in the water phase. Assumptions were based on Phase 1 observations.)

Reductions of volatile, semivolatile and PCBs were also observed. Volatile hazardous organic compounds were reduced (via biodegradation and volatilization) below the level of detection in all three reactors. Semivolatile hazardous organic compounds were reduced by 84 to 86 percent in each reactor. Detection limits were used as the actual concentration in these calculations. More variability occurred in the level of PCB removal between the reactors (based on Aroclor analyses). Reactor 2200, which used the General Electric micro-organisms appears to have shown a PCB reduction of 53 percent. The Microbe Masters microorganisms used in Reactor 2300 appear to have resulted in a 44 percent reduction in PCB mass. Reactor 2100 used native microorganisms and appears to have resulted in a 43 percent reduction in PCBs.

The detailed mass balances are presented in Tables C-4 through C-6.

A GC/MS analytical method (Method 680) was used to measure congener distributions within the samples. Although it proved not to be accurate for determining precise concentrations, the data developed are useful for detecting biodegradation. In general, congeners with fewer chlorine atoms attached are more readily biodegraded than more highly chlorinated congeners. A shift in

TABLE C-2

PHASE 2 BIOLOGICAL TREATABILITY STUDY
ANALYTICAL RESULTS

PARAMETER	Time Zero (November 20, 1987) Reactor 2100 Native Ogranisms Water Phase	Reactor 2200 GE Water Phase	Reactor 2300 MicrobeMasters Water Phase	Average Raw Sludge (from Table C-1)	Day 71 (January 29, 1988) Reactor 2100 Native Microbes Water Phase	Reactor 2100 Native Microbes Solid Phase	Reactor 2200 GE Microbes Water Phase	Reactor 2200 GE Microbes Solid Phase	Reactor 2300 Microbe Masters Water Phase	Reactor 2300 Microbe Masters Solid Phase
VOLATILES										
Benzene (mg/kg) **	3.4	3.9	3.5	196.7	0.005 *	0.5 *	0.005 *	0.5 *	0.005 *	0.5 *
Ethylbenzene (mg/kg)	5.6	2.7	3.2	771.7	0.005 *	0.5 *	0.005 *	0.5 *	0.005 *	0.5 *
Styrene (mg/kg)	3.7	2.3	2.3	451.7	0.005 *	0.5 *	0.005 *	0.5 *	0.005 *	0.5 *
Tetrachloroethene (mg/kg)	0.6 *	0.5 *	0.5 *	59.2	0.005 *	0.5 *	0.005 *	0.5 *	0.005 *	0.5 *
Toluene (mg/kg)	6.0	6.0	6.1	840.0	0.005 *	0.5 *	0.005 *	0.5 *	0.005 *	0.5 *
Total Xylenes (mg/kg)	18.5	40.5	10.0	2283.3	0.005 *	0.5 *	0.005 *	0.5 *	0.005 *	0.5 *
SEMIVOLATILES										
bis(2-Ethylhexyl)phthalate (mg/kg)	0.1 *	0.1 *	0.1 *	54.5	0.2 *	300	0.2 *	330	2 *	170
Fluoranthene (mg/kg)	0.2	0.1 *	0.1 *	47.7	0.2 *	9.2	0.2 *	49 *	2 *	66
2-Methylnaphthalene (mg/kg)	0.8	0.3	0.4	190.0	0.2 *	58 *	0.2 *	49 *	2 *	59 *
Naphthalene (mg/kg)	1.0	0.5	0.6	216.7	0.2 *	58 *	0.2 *	49 *	2 *	59 *
N-Nitrosodiphenylamine (mg/kg)	1.2	0.1 *	0.3 *	217.3	0.2 *	58 *	0.2 *	49 *	2 *	59 *
Phenanthrene (mg/kg)	0.5	0.2	0.2	103.7	0.2 *	63	0.2 *	49 *	2 *	59 *
2,4-Dimethylphenol (mg/kg)	9.0	7.3	8.5	288.3	0.2 *	58 *	0.2 *	49 *	2 *	59 *
2-Methylphenol (mg/kg)	10.0	7.4	10.4	186.7	0.2 *	58 *	0.2 *	49 *	2 *	59 *
4-Methylphenol (mg/kg)	32.0	20.5	32.5	383.3	0.2 *	58 *	0.2 *	49 *	2 *	59 *
Phenol (mg/kg)	67.0	43.5	70.5	693.3	0.2 *	58 *	0.2 *	49 *	2 *	59 *
PCB'S										
Aroclor-1242 (ug/kg)	265.0	88.0	205.0	70,500	1.5 *	72,000	3	67,000	1.5 *	99,000
Aroclor-1260 (ug/kg)	985.0	300.0	650.0	313,333	42	300,000	110	230,000	36	340,000
Monochlorobiphenyls (ug/kg)	37.0	5.0	8.5	1,293	ND (a)	270	ND (a)	300	ND (a)	310
Dichlorobiphenyls (ug/kg)	56.5	14.2	26.0	5,575	ND (a)	3,900	ND (a)	3,600	ND (a)	5,700
Trichlorobiphenyls (ug/kg)	92.5	35.5	40.0	12,283	3.4	19,000	3.1	20,000	ND (a)	29,000
Tetrachlorobiphenyls (ug/kg)	80.0	19.0	31.0	10,567	ND (a)	10,000	ND (a)	15,000	ND (a)	25,000
Pentachlorobiphenyls (ug/kg)	86.0	36.0	26.5	10,100	1.8	24,000	6.4	34,000	ND (a)	42,000
Hexachlorobiphenyls (ug/kg)	295.0	77.0	128.0	33,000	15	100,000	29	120,000	9.8	140,000
Heptachlorobiphenyls (ug/kg)	184.5	37.5	85.0	22,167	5.7	58,000	20	73,000	3.2	80,000
Octachlorobiphenyls (ug/kg)	32.5	10.0	24.0	5,700	ND (a)	12,000	2.9	12,000	ND (a)	16,000
Nonachlorobiphenyls (ug/kg)	ND (a)	ND (a)	ND (a)		ND (a)	ND (a)	ND (a)	ND (a)	ND (a)	ND (a)
Decachlorobiphenyl (ug/kg)	ND (a)	ND (a)	ND (a)		ND (a)	ND (a)	ND (a)	ND (a)	ND (a)	ND (a)
PHYSICAL CHARACTERISTICS										
Oil (%)	NA	NA	NA	34.1	NA	47.5	NA	43	NA	50.5
Water (%)	NA	NA	NA	52.2	NA	30.1	NA	32.7	NA	25.7
Solids (%)	NA	NA	NA	13.7	NA	22.4	NA	24.3	NA	23.8
Ash @ 550 C (%) (Dry weight basis)	0.336	0.3	0.297	26.3	0.69	26.5	0.54	27.7	0.5155	26.8
Total Solids (%)	0.7115	0.694	0.714	43.7	0.5515 (b)	73.9	0.6065	70.2	0.57	76.2
Specific Gravity (@ 77 F)						1.1646		1.1881		1.1916

NOTES:

NA = Not Analyzed
(a) ND = Not detected, detection limit not determined.
(b) Total Solids and Total Ash contents of water samples are calculated based on the sum of Total Dissolved Solids plus the Total Suspended Solids, and for ash, minus the volatile suspended solids.
* Reported value is method detection limit or for water samples (which are average of two samples) where at least one sample was below detection limit.
** Density of water is assumed to be 1 kg/L

C-4

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TABLE C-3

Summary Of Phase 2 Mass Balances

Sheridan Site Committee

May 16, 1988

PARAMETER	TIME ZERO TOTAL MASS [grams]	Reactor 2100 Native Microorganisms Mass Day 71 [grams]	Reactor 2100 Native Microorganisms % Removal DAY 71 (%)	Reactor 2200 GE Microorganisms Mass Day 71 [grams]	Reactor 2200 GE Microorganisms % Removal DAY 71 (%)	Reactor 2300 Microbe Masters Mass Day 71 [grams]	Reactor 2300 Microbe Masters % Removal DAY 71 (%)
WATER MASS	57240	57240	0.0	57240	0.0	57240	0.0
SLUDGE MASS (Wet Weight)	7296	4302	41.0	4370	40.1	3620	49.3
TOTAL SOLIDS (Dry Weight)	3187	3179	0.2	3067	3.8	2777	12.9
OIL AND GREASE	2178 [a]	1852 [b]	15.0	1678 [b]	23.0	1625	25.4
TOTAL DETECTED VOLATILES	31.57	0.01	100.0	0.01	100.0	0.01	100.0
TOTAL DETECTED SEMIVOLATILES	22.12	3.13	85.9	3.30	84.3	3.41	84.7
TOTAL DETECTED PCB'S [c]	2.51	1.44	42.6	1.16	53.0	1.40	43.6

Notes

[a] Assumes 100 ppm oil and grease in the water

[b] Assumes 200 ppm oil and grease in the water

[c] Based on Aroclor analyses (Method 608)

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TABLE C-[illegible]

Detailed Mass Balance - Reactor 2100
Phase 2 Biodegradation Study

Sheridan Disposal Site Feasibility Study

PARAMETER	Time Zero [a] (November 20 1987) Water Conc (as noted)	Water Mass (grams)	Sludge Conc (as noted)	Sludge Mass (grams)	Total Mass (grams)	Mass in Reactor 2100 - Native Microorganisms (January 29 1988) Water Conc (as noted)	Water Mass (grams)	Sludge Conc (as noted)	Sludge Mass (grams)	Total Mass (grams)	Percent Mass Removed (%)
WATER MASS		57240			57240		57240			57240	0 0
SLUDGE MASS (WET wt %)	NA	932		6364	729		427		3875 [d]	4302	41 0
SLUDGE MASS (DRY wt %)	0 71	407	43 7	2780	3187	0 5515 [b]	316	73 9	2864	3179	0 2
OIL & GREASE (wt %)	0 01 [c]	6	34 1	2172	21 1	0 02 [c]	11	47 5	1841	1852	15 0
VOLATILES											
Benzene (mg/kg) **	3 4	0 195	196 7	1 252	1 446	0 005 *	000	0 5 *	0 002	0 002	99 8
Ethylbenzene (mg/kg)	5 6	0 318	771 7	4 911	5 229	0 005 *	000	0 5 *	0 002	0 002	100 0
Styrene (mg/kg)	3 7	0 212	451 7	2 874	3 086	0 005 *	000	0 5 *	0 002	0 002	99 9
Tetrachloroethene (mg/kg)	0 6	0 037	59 2	0 377	0 413	0 005 *	000	0 5 *	0 002	0 002	99 5
Toluene (mg/kg)	8 0	0 455	840 0	5 346	5 801	0 005 *	000	0 5 *	0 002	0 002	100 0
Total Xylenes (mg/kg)	18 5	1 059	2283 3	14 531	15 590	0 005 *	000	0 5 *	0 002	0 002	100 0
TOTAL DETECTED VOLATILES		2 275		29 290	31 565		0 002		0 012	0 013	100 0
SEMIVOLATILES											
bis(2-Ethylhexyl)phthalate (mg/kg	0 1	0 006	54 5	0 347	0 353	0 2 *	0 011	300	1 163	1 174	-231 0
Fluoranthene (mg/kg)	0 2	0 013	47 7	0 303	0 317	0 2 *	0 011	9 2	0 036	0 047	85 1
2-Methylnaphthalene (mg/kg)	0 8	0 044	190 0	1 209	1 253	0 2 *	0 011	58 *	0 225	0 236	81 2
Naphthalene (mg/kg)	1 0	0 058	216 7	1 379	1 437	0 2 *	0 011	58 *	0 225	0 236	83 6
N-Nitrosodiphenylamine (mg/kg)	1 2	0 069	217 3	1 383	1 452	0 2 *	0 011	58 *	0 225	0 236	83 7
Phenanthrene (mg/kg)	0 5	0 027	103 7	0 660	0 686	0 2 *	0 011	63	0 244	0 256	62 8
2,4-Dimethylphenol (mg/kg)	9 0	0 512	288 3	1 835	2 347	0 2 *	0 011	58 *	0 225	0 236	89 9
2-Methylphenol (mg/kg)	10 0	0 572	186 7	1 188	1 760	0 2 *	0 011	58 *	0 225	0 236	86 6
4-Methylphenol (mg/kg)	32 0	1 832	383 3	2 440	4 271	0 2 *	0 011	58 *	0 225	0 236	94 5
Phenol (mg/kg)	67 0	3 835	693 3	4 412	8 247	0 2 *	0 011	58 *	0 225	0 216	97 1
TOTAL DETECTED SEMIVOLATILES		6 969		15 156	22 125		0 114		3 016	3 130	85 9
PCB'S											
Aroclor-1242 (ug/kg)	265 0	0 015	70 500	0 449	0 464	1 5 *	000	72 000	0 279	0 279	39 8
Aroclor-1260 (ug/kg)	985 0	0 056	313 333	1 994	2 050	42	0 002	300 000	1 163	1 165	43 2
TOTAL DETECTED AROCLORS		0 072		2 443	2 5[illegible]		0 002		1 442	1 444	42 6
Monochlorobiphenyls (ug/kg)	37 0	0 002	1 293	0 008	0 0[illegible]	ND	0 000	270	0 001	0 001	
Dichlorobiphenyls (ug/kg)	56 5	0 003	5.575	0 035	0 03[illegible]	ND	0 000	3 900	0 015	0 015	
Trichlorobiphenyls (ug/kg)	92 5	0 005	12.283	0 078	0 08[illegible]	3 4	000	19 000	0 074	0 074	
Tetrachlorobiphenyls (ug/kg)	80 0	0 005	10 567	0 067	0 072	ND	0 000	10 000	0 039	0 039	
Pentachlorobiphenyls (ug/kg)	86 0	0 005	10 100	0 064	0 06[illegible]	1 8	000	24 000	0 093	0 093	
Hexachlorobiphenyls (ug/kg)	295 0	0 017	33 000	0 210	0 227	15	0 001	100 000	0 388	0 388	
Heptachlorobiphenyls (ug/kg)	184 5	0 011	22 167	0 141	0 152	5 7	000	58 000	0 225	0 225	
Octachlorobiphenyls (ug/kg)	32 5	0 002	5 700	0 036	0 0[illegible]	ND	0 000	12 000	0 047	0 047	
Nonachlorobiphenyls (ug/kg)	ND [a]		ND			ND		ND			
Decachlorobiphenyl (ug/kg)	ND		ND			ND		ND			

NOTES
- NA = Not Analyzed
- [a] ND = Not Detected detection limit not determined for congener analysis
- [b] Total Solids and Total Ash contents of water samples are calculated based on the sum of the Total Dissolved Solids plus the Total Suspended Solids and for ash minus the Volatile Suspended Solids
- [c] Assumed value
- [d] Measured weight of sludge residue plus 75 grams removed incidentally during maintenance
- * Reported value is method detection limit
- ** Density of water is assumed to be 1 kg/l

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TABLE C-5

Detailed Mass Balance - Reactor 2200
Phase 2 Biodegradation Study

Sheridan Disposal Site Feasibility Study

PARAMETER	Time Zero [a] (November 20 1987) Water Conc (as noted)	Water Mass (grams)	Sludge Conc (as noted)	Sludge Mass (grams)	Total Mass (grams)	Mass in Reactor 2200 - GE Microorganisms (January 29 1988) Water Conc (as noted)	Water Mass (grams)	Sludge Conc (as noted)	Sludge Mass (grams)	Total Mass (grams)	Percent Mass Removed (%)
WATER MASS		57240			57240		57240			57240	0.0
SLUDGE MASS (WET, wt %)	NA	932		6364	7296		495		3875 [d]	4370	40.1
SLUDGE MASS (DRY, wt %)	0.71	407	41.7	2780	3187	0.6065 [b]	347	70.2	2720	3067	3.8
OIL & GREASE (wt %)	0.01 [c]	6	34.1	2172	2178	0.02 [c]	11	41	1666	1678	23.0
VOLATILES											
Benzene (mg/kg) **	3.9	0.220	196.7	1.252	1.472	0.005 *	000	0.5 *	0.002	0.003	99.8
Ethylbenzene (mg/kg)	2.7	0.152	771.7	4.911	5.063	0.005 *	000	0.5 *	0.002	0.002	100.0
Styrene (mg/kg)	2.3	0.129	451.7	2.874	3.003	0.005 *	000	0.5 *	0.002	0.002	99.9
Tetrachloroethene (mg/kg)	0.5 *	0.029	59.2	0.377	0.405	0.005 *	000	0.5 *	0.002	0.002	99.5
Toluene (mg/kg)	6.0	0.343	840.0	5.346	5.639	0.005 *	000	0.5 *	0.002	0.002	100.0
Total Xylenes (mg/kg)	40.5	2.318	2283.3	14.531	16.819	0.005 *	000	0.5 *	0.002	0.002	100.0
TOTAL DETECTED VOLATILES		3.191		29.290	32.481		0.002		0.012	0.013	100.0
SEMIVOLATILES											
bis(2-Ethylhexyl)phthalate (mg/kg)	0.1 *	0.006	54.5	0.347	0.353	0.2 *	0.011	330	1.279	1.290	265.9
Fluoranthene (mg/kg)	0.1 *	0.006	47.7	0.303	0.309	0.2 *	0.011	49 *	0.190	0.201	34.9
2-Methylnaphthalene (mg/kg)	0.3	0.017	190.0	1.209	1.2[illegible]7	0.2 *	0.011	49 *	0.190	0.201	81.6
Naphthalene (mg/kg)	0.5	0.026	216.7	1.379	1.405	0.2 *	0.0[illegible]	49 *	0.190	0.2[illegible]	85.7
N-Nitrosodiphenylamine (mg/kg)	0.1 *	0.006	217.3	1.383	[illegible]	0.2 *	0.011	49 *	0.190	0.201	85.5
Phenanthrene (mg/kg)	0.2	0.010	103.7	0.660	0.6[illegible]0	0.2 *	0.011	49 *	0.190	0.201	70.0
2,4-Dimethylphenol (mg/kg)	7.3	0.415	288.3	1.835	2.2[illegible]	0.2 *	0.011	49 *	0.190	0.201	91.1
2-Methylphenol (mg/kg)	7.4	0.421	186.7	1.188	1.6[illegible]9	0.2 *	0.011	49 *	0.190	0.201	87.5
4-Methylphenol (mg/kg)	20.5	1.173	383.3	2.440	3.61[illegible]	0.2 *	0.011	49 *	0.190	0.201	94.4
Phenol (mg/kg)	43.5	2.490	693.3	4.412	[illegible]	0.2 *	0.011	49 *	0.190	0.201	97.1
TOTAL DETECTED SEMIVOLATILES		4.570		15.156	1[illegible].[illegible]26		0.114		2.988	3.102	84.[illegible]
PCB'S											
Aroclor-1242 (ug/kg)	88.0	0.005	70 500	0.449	0.454	3	000	67 000	0.260	0.260	42.7
Aroclor-1260 (ug/kg)	300.0	0.017	313 333	1.994	2.011	110	0.006	230 000	0.891	0.898	55.4
TOTAL DETECTED AROCLORS		0.022		2.443	2.465		0.006		1.151	1.157	53.0
Monochlorobiphenyls (ug/kg)	5.0	000	1 293	0.008	0.009	ND	0.000	300	0.001	0.001	
Dichlorobiphenyls (ug/kg)	14.2	0.001	5 575	0.035	0.036	ND	0.000	3 600	0.014	0.014	
Trichlorobiphenyls (ug/kg)	35.5	0.002	12 283	0.078	0.080	3.1	000	20 000	0.078	0.078	
Tetrachlorobiphenyls (ug/kg)	19.0	0.001	10 567	0.067	0.068	ND	0.000	15 000	0.058	0.058	
Pentachlorobiphenyls (ug/kg)	36.0	0.002	10 100	0.064	0.066	6.4	000	34 000	0.132	0.132	
Hexachlorobiphenyls (ug/kg)	77.0	0.004	33 000	0.210	0.214	29	0.002	120 000	0.465	0.467	
Heptachlorobiphenyls (ug/kg)	37.5	0.002	22 167	0.141	0.143	20	0.001	73 000	0.283	0.284	
Octachlorobiphenyls (ug/kg)	10.0	0.001	5 700	0.036	0.037	2.9	000	12 000	0.047	0.047	
Nonachlorobiphenyls (ug/kg)	ND [a]		ND			ND		ND			
Decachlorobiphenyl (ug/kg)	ND		ND			ND		ND			

NOTES
- NA = Not Analyzed
- [a] ND = Not Detected, detection limit not determined for congener analysis
- [b] Total Solids and Total Ash contents of water samples are calculated based on the sum of the Total Dissolved Solids plus the Total Suspended Solids and ... ash minus the Volatile Suspended Solids
- [c] Assumed value
- [d] Measured weight of sludge residue plus 75 grams removed incidentally during maintenance
- * Reported value is method detection limit
- ** Density of water is assumed to be 1 kg/L

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TABLE C-6

Detailed Mass Balance - Reactor 2300
Phase 2 Biodegradation Study

Sheridan Disposal Site - Feasibility Study

PARAMETER	Time Zero [a] (November 20 1987) Water Conc (as noted)	Water Mass (grams)	Sludge Conc (as noted)	Sludge Mass (grams)	Total Mass (grams)	Mass in Reactor 2300 - Microbe Masters (January 29 1988) Water Conc (as noted)	Water Mass (grams)	Sludge Conc (as noted)	Sludge Mass (grams)	Total Mass (grams)	Percent Mass Removed (%)
WATER MASS		57240			57240		57240			57240	0 0
SLUDGE MASS (WET wt %)	NA	780		6364	7144		425		3195 [d]	3620	49 3
SLUDGE MASS (DRY wt %)	0 71	407	43 7	2780	3187	0 57 [b]	326	76 7	2451	2777	12 9
OIL & GREASE (wt %)	0 01 [c]	6	34 1	2172	2178	0 02 [c]	11	50 5	1613	1625	25 4
VOLATILES											
Benzene (mg/kg) **	3 5	0 200	196 7	1 252	1 4[illegible]2	0 005 *	000	0 5	0 002	0 002	99 9
Ethylbenzene (mg/kg)	3 2	0 180	771 7	4 911	5 09[illegible]	0 005 *	000	0 5	0 002	0 002	100 0
Styrene (mg/kg)	2 3	0 129	451 7	2 874	3 [illegible]	0 005 *	000	0 5	0 002	0 002	99 9
Tetrachloroethene (mg/kg)	0 5 *	0 029	59 2	0 377	0 40[illegible]	0 005 *	000	0 5	0 002	0 002	99 5
Toluene (mg/kg)	6 1	0 349	840 0	5 346	5 6[illegible]5	0 005 *	000	0 5	0 002	0 002	100 0
Total Xylenes (mg/kg)	10 0	0 572	2283 3	14 531	15 [illegible]04	0 005 *	000	0 5	0 002	0 002	100 0
TOTAL DETECTED VOLATILES		1 460		29 290	30 7[illegible]		0 002		0 010	0 011	100 0
SEMIVOLATILES											
bis(2-Ethylhexyl)phthalate (mg/kg)	0 1 *	0 006	54 5	0 347	0 35[illegible]	2 *	0 114	170	0 543	0 658	-86 3
Fluoranthene (mg/kg)	0 1 *	0 006	47 7	0 303	0 3[illegible]0	2 *	0 114	66	0 211	0 325	-5 1
2-methylnaphthalene (mg/kg)	0 4	0 022	190 0	1 209	1 231	2 *	0 114	59	0 189	0 303	75 4
Naphthalene (mg/kg)	0 6	0 034	216 7	1 379	1 41[illegible]	2 *	0 114	59	0 189	0 303	78 6
N-Nitrosodiphenylamine (mg/kg)	0 3 *	0 017	217 3	1 383	1 40[illegible]	2 *	0 114	59	0 189	0 303	78 4
Phenanthrene (mg/kg)	0 2	0 013	103 7	0 660	0 673	2 *	0 114	59	0 189	0 303	55 0
2,4-Dimethylphenol (mg/kg)	8 5	0 484	288 3	1 835	2 3[illegible]9	2 *	0 114	59	0 189	0 303	86 9
2-methylphenol (mg/kg)	10 4	0 595	186 7	1 188	1 783	2 *	0 114	59	0 189	0 303	83 0
4-methylphenol (mg/kg)	32 5	1 860	383 3	2 440	4 300	2 *	0 114	59	0 189	0 303	93 0
Phenol (mg/kg)	70 5	4 035	693 3	4 412	8 4[illegible]	2 *	0 114	59	0 189	0 303	96 4
TOTAL DETECTED SEMIVOLATILES		7 072		15 156	22 228		1 145		2 262	3 407	84 7
PCB'S											
Aroclor-1242 (ug/kg)	205 0	0 012	70 500	0 449	0 463	1 5 *	000	99 000	0 316	0 316	3[illegible]
Aroclor-1260 (ug/kg)	650 0	0 037	313 333	1 994	2 031	36	0 002	340 000	1 086	1 088	46 4
TOTAL DETECTED AROCLORS		0 049		2 443	2 4[illegible]2		0 002		1 401	1 405	43 6
Monochlorobiphenyls (ug/kg)	8 5	000	1 293	0 008	0 0[illegible]	ND	0 000	310	0 001	0 001	
Dichlorobiphenyls (ug/kg)	26 0	0 001	5 575	0 035	0 0[illegible]	ND	0 000	5 700	0 018	0 018	
Trichlorobiphenyls (ug/kg)	40 0	0 002	12 283	0 078	0 0[illegible]	ND	0 000	29 000	0 093	0 093	
Tetrachlorobiphenyls (ug/kg)	31 0	0 002	10 567	0 067	0 0[illegible]9	ND	0 000	25 000	0 080	0 080	
Pentachlorobiphenyls (ug/kg)	26 5	0 002	10 100	0 064	0 0[illegible]	ND	0 000	42 000	0 134	0 134	
Hexachlorobiphenyls (ug/kg)	128 0	0 007	33 000	0 210	0 2[illegible]	9 8	0 001	140 000	0 447	0 448	
Heptachlorobiphenyls (ug/kg)	85 0	0 005	22 167	0 141	0 1[illegible]	3 2	000	80 000	0 256	0 256	
Octachlorobiphenyls (ug/kg)	24 0	0 001	5 700	0 036	0 0[illegible]	ND	0 000	16 000	0 051	0 051	
Nonachlorobiphenyls (ug/kg)	ND [a]		ND			ND		ND			
Decachlorobiphenyl (ug/kg)	ND		ND			ND		ND			

NOTES
- NA - NG Analyzed
- [a] ND - Not Detected, detection limit not determined for congener analysis
- [b] Total Solids and Total Ash contents of water samples are calculated based on the sum of the Total Dissolved Solids plus the Total Suspended Solids and for ash minus the Volatile Suspended Solids
- [c] Assumed value
- [d] Measured weight of sludge residue plus 75 grams removed incidentally during maintenance
- * Reported value is method detection limit
- ** Density of water is assumed to be 1 kg/l

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the distribution of congeners within a reactor therefore can be an indication of biodegradation. The distribution of congeners in each reactor at day 71 are plotted against the initial congener distribution in the sludge in Figure C-1. For the time zero data, 95% confidence intervals around the congener data were calculated and are shown in Figure C-1. A significant reduction in the relative proportions of mono through penta chlorobiphenyls indicates that significant biodegradation of PCBs may have occurred. The degree of the shifts also corresponds well to the relative amount of reduction observed between reactors, (i.e. Reactor 2200 showed more reduction by both analytical methods than Reactor 2100, which showed more than Reactor 2300 by both methods). The conclusions based upon these data should be considered tentative due to the state of development of the GC/MS PCB analysis.

The reactors were shut down after 186 days of operation (May 24, 1988). The wet weight of residue in the bottom of each reactor was measured and samples of the residue were frozen for possible future analysis. Very little additional reduction in wet mass occurred in any of the reactors between day 71 and day 186.

PHASE SEPARATION STUDY

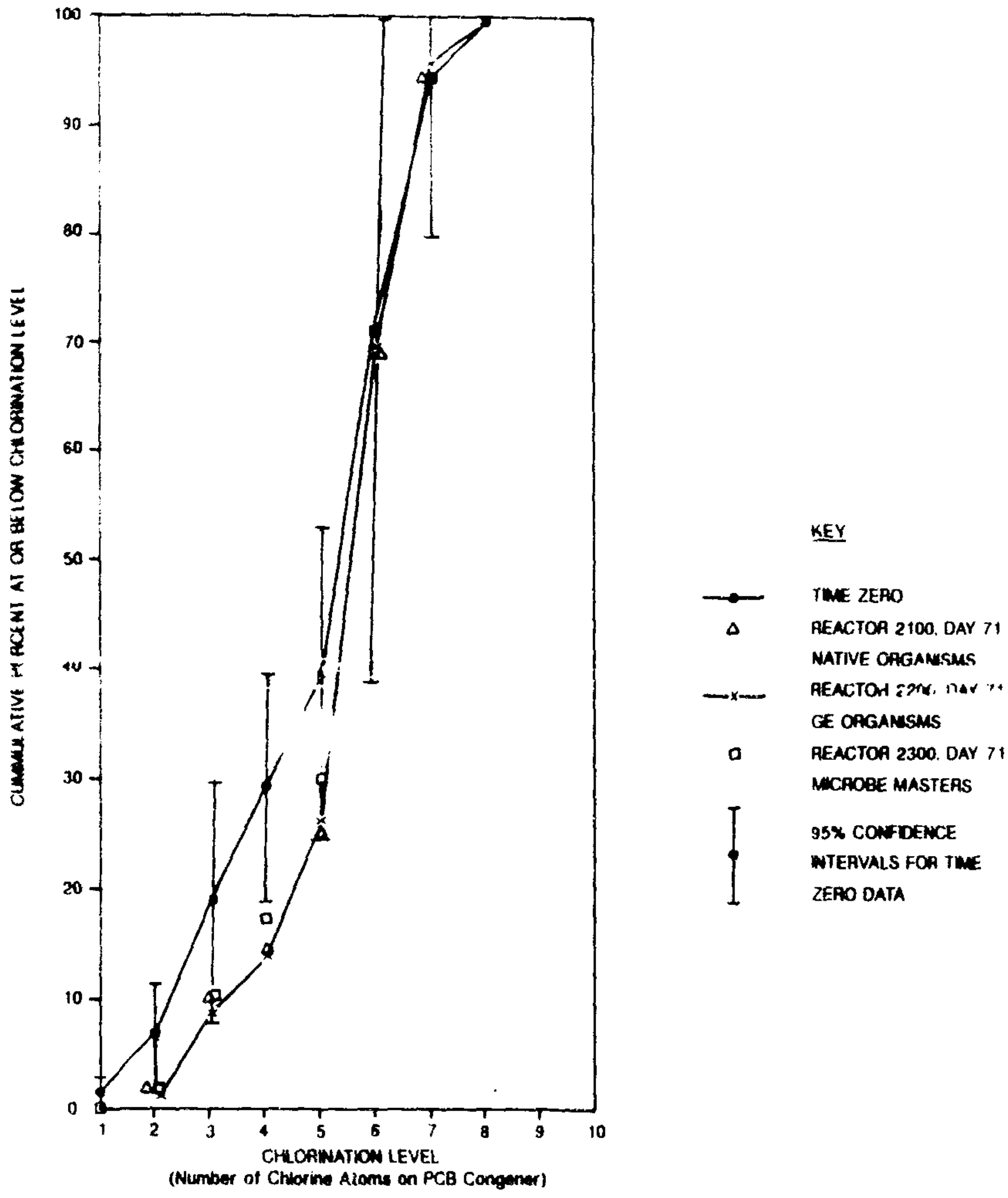
As a supplement to this biodegradation study, a short study was conducted to investigate the phase separation phenomenon which occurs during biological treatment of the sludge in stirred reactors. Initially, 31.5 pounds of pond water and 3.5 pounds of sludge were added to a six gallon reactor with a 1/15 HP mixer. Volt and amp measurements on the power supply to the mixer were used to monitor the mixing energy in the reactor. Mixing energy was maintained at high levels relative to that typically required for activated sludge (i.e. 4.5 HP/1000 ft^3 or more compared to 0.6 to 1.15 HP/1000 ft^3).

Phase separation occurred within 24 hours and tar ball formation occurred within one week. Within two weeks the tar balls had become relatively firm and did not tend to agglomerate together in large masses. The size of the balls decreased with time and were 1/8 to 1/4 inch in diameter or less at the end of two to three weeks.

Higher mixing energies (>8 HP/1000 ft^3) caused an increase in the size of the tar balls. This phenomenon was apparently due to a snowballing effect from the rolling of tar balls around the edge of the reactor.

COMPOST REACTORS

Drs. Bumpus and Aust of Utah State University (both previously of Michigan State University) have been working with a lignin degrading White Rot Fungus for several years and have published



011135

ERM-Southwest, Inc. NEW ORLEANS, LOUISIANA HOUSTON, TEXAS	FIGURE C-1 CONGENER DISTRIBUTIONS PHASE 2 BIOTREATMENT STUDY
DATE 8/25/88 W.O.NO. 9101A036	

numerous papers documenting the ability of this fungus to degrade many compounds which are otherwise resistant to biodegradation. The ability of the White Rot Fungus to degrade PCBs in the Sheridan Pond Sludge was assessed in three compost reactors in which sludge was mixed with wood chips at ratios of 1:4 and 1:8 and seeded at two ratios with an active White Rot Fungus start-up culture. None of the three compost reactors showed any promise of sustainable activity and no samples were taken for analysis after day 32 of the study.

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APPENDIX D

Stabilization and Solvent Extraction Report

011137

PHASE 1 STABILIZATION AND SOLVENT EXTRACTION
TREATABILITY TESTING REPORT
FOR
SOURCE CONTROL FEASIBILITY STUDY

Sheridan Site Committee
Sheridan Disposal Services Site
Hempstead, Texas

011138

Chris E. Tanner, P.E.

May 23, 1988

W.O. #91-12

Douglas S. Diehl, P.E.
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APPENDICES

SUMMARY

A variety of treatment technologies were evaluated in parallel with the production of the Sheridan Disposal Services site Source Control Feasibility Study. This report summarizes the testing of stabilization and solvent extraction to develop site-specific data as a basis for assessing the feasibility of these technologies. Stabilization was found to be sufficiently feasible to develop a basis of design for use in the Source Control Feasibility Study in determining the cost of stabilization alternatives.

Stabilization was tested by stabilizing a composite representative sample of pond sludge with stabilization blends that variously included fly ash, Portland cement, quick lime, rice hull ash, sodium carbonate, sodium silicate and soil.

These admixes were evaluated based on their relative ability to control constituent leachability and to meet an engineering criteria of 15 psi unconfined compressive strength. Admixes without soil were found to reduce the leachability of volatile organics by half. Leachability of semivolatile organics was not measured. Admixes without soil were found to shrink after mixture with the pond sludge, and to produce free water that must then be drained and treated, but admixes with soil eliminated shrinkage and the production of free water. Admixes with and without soil were able to meet engineering criteria for strength. The stabilization system used as a basis of design was a soil and fly ash admix blended in-situ with a backhoe and a proprietary injector/blender mounted on a backhoe.

Solvent extraction was considered for pretreatment for incineration. The suitability of this combination of technologies is evaluated in this report.

PHASE 1 STABILIZATION AND SOLVENT EXTRACTION
TREATABILITY TESTING REPORT
FOR
SOURCE CONTROL FEASIBILITY STUDY

1 - INTRODUCTION

Review of remedial action alternatives early in the Feasibility Study process indicated that certain treatment technologies held important promise for the remediation of this site. The effectiveness of these technologies was expected to be site or waste specific, necessitating testing on materials representative of the site. For this reason, a representative composite sample of pond sludge was collected for treatment testing. The pond sludge was fully characterized and bench tests for biological treatment, solvent extraction and stabilization were conducted. Incineration was developed as a concept design based on characterization data. Biological treatment and incineration results are discussed in separate documents and stabilization and solvent extraction testing are discussed herein.

Stabilization includes a variety of pozzolanic and cementatious processes that have been developed to incorporate dissolved constituents in wastes and sludges as a part of a rigid matrix. Heavy metals react to form immobile colloidal hydroxides and large organic molecules become effectively immobilized.

Solvent extraction is a broad term used in industrial solid waste treatment to identify treatment technologies that use solvents to segregate sludges into discrete oil, water and solids fractions for subsequent treatment or disposal. The resulting oil phase can be incinerated or possibly recycled and burned as a fuel, the resulting water can be evaporated or treated and discharged, and the resulting solids can be landfilled.

Note that there are treatment technologies that segregate sludges into oil, water and solids without solvent extraction such as chemical treatment followed by physical separation in a centrifuge.

The following sections describe solvent extraction technologies in more detail, present testing methodologies and results, summarize laboratory and vendor data, and develop concept designs if the technologies prove to be feasible.

011141

2 - STABILIZATION TESTING

2.1 General

For ease of reference, the term "stabilization" in this report is used interchangeably with the terms "solidification" and "fixation". These terms are defined in the EPA publication, "Guide to the Disposal of Chemically Stabilized and Solidified Waste" (Malone et al. 1980). Stabilization and solidification both refer to waste treatment processes that make the waste easier to handle, decrease the surface area of the waste mass across which transfer or loss of waste constituents can occur, and limit the solubility of the waste constituents. The term "fixation" is also used in the waste treatment field to describe a process that might also be described as stabilization or solidification.

011142

Most stabilization systems being marketed today are proprietary processes involving the addition of absorbents and solidifying agents to a waste, and the processes are often changed to deal with specific wastes. The EPA's "Handbook for Stabilization/ Solidification of Hazardous Wastes" (Army Engineer Waterways Experiment Station, Vicksburg, 1986) lists and explains in considerable detail the following systems that are potentially useful in remedial action:

a. Lime-fly ash pozzolan processes
b. Pozzolan-Portland cement systems
c. Thermoplastic microencapsulation
d. Macroencapsulation

Lime/fly ash pozzolanic processes use a finely divided, non-crystalline silica in fly ash and the calcium in lime to produce low-strength cementation. The waste containment is produced by entrapping the waste in the pozzolan concrete matrix (microencapsulation).

Pozzolan-Portland systems use Portland cement and fly ash or other pozzolan materials to produce a stronger type of waste/ concrete composite. The waste containment is produced by microencapsulation in the concrete matrix. Soluble silicates may be added to accelerate hardening and metal containment.

Thermoplastic microencapsulation involves blending fine particulate waste with melted asphalt or other matrix. Liquid and volatile phases associated with the wastes are driven off, and the wastes are isolated in a mass of cooled, hardened asphalt. The material can be buried with or without a container.

Macroencapsulation systems contain a waste by isolating large masses of waste using some type of jacketing material. The most carefully researched systems use a drum or a polyethylene jacket fused over a monolithic block of solidified wastes.

The processes tested for remediation utilize lime-fly ash pozzolan processes and/or pozzolan-Portland cement systems. Thermoplastic microencapsulation was not evaluated because solvent constituents in the waste are not likely to be compatible with the asphaltic encapsulation matrix. Macroencapsulation was not evaluated because it is labor-intensive and would be prohibitively expensive considering the large volume of the pond sludge.

2.2 Objectives

The objectives of solidification are to: 1) reduce the mobility and toxicity of the waste and 2) increase the strength of the waste for handling, trafficability and structural support. The strength of the stabilized waste is measured against engineering criteria established for the site.

2.3 Engineering Criteria for Strength

The "Handbook for Stabilization/Solidification of Hazardous Wastes" (USEPA 1986. PB87-116745) shows two methods of determining the ability of a waste to support a load. The cone index or California bearing ratio (U.S. Army 1972) involves forcing a standard cone into a sample of soil. It is typically used to examine the trafficability of a subgrade soil. The unconfined compressive (UC) strength (U.S. Army 1972. ASTM D2166-66) measures the bearing capacity and shear strength of cohesive or cemented materials.

The initial (as mixed) strength of the stabilized material is also a practical indicator and the UC strength of the material should be at least 5 psi for ease of handling. Strength, and therefore handleability (and trafficability), increase with time, however. Some mix designs have no initial strength and almost flow like a cement grout, yet harden into a concrete-like monolithic mass.

The 24-hour strength of the stabilized material should be sufficient to support and be handled and compacted by conventional earthworking equipment. Conventional track-type loaders exert ground pressures of 8.9 to 11.9 psi (65 to 210 HP). Equivalent low ground pressure track-type loaders exert ground pressures of 4.7 to 9.1 psi (Caterpillar Performance Handbook 1986). The 24-hour UC strength for trafficability should thus be at least ten psi, and one contractor uses 14-15 psi as a rule of thumb. The important strength of the stabilized material is not necessarily related to long-term structural soundness, however. The material's ability to support the entire load of the landfilled waste and landfill cap is relatively unlimited as long as it is adequately confined.

2.4 Previous Testing

In 1985, the Sheridan Steering Committee evaluated sludge stabilization to develop a conceptual design for closure based on engineering criteria for strength. This evaluation focused on the stabilization of pond sludge to allow earthmoving equipment to operate over the stabilized mass and to attain sufficient load bearing capacity to support a cap.

A laboratory testing procedure was established based upon the use of the shear strength of stabilized sludge samples as an indication of the cohesiveness of the materials. It is known that for shallow footings a relationship exists between measured shear strength and ultimate load bearing capacity, where bearing capacity was about five times shear strength. Since hydration of the admix materials over time would have an impact upon cohesiveness, samples were premixed and sealed in plastic bags for varying periods of time prior to testing. It was determined by shear strength testing of control samples that a 72-hour "cure time" would provide reproducible results.

Both quick lime and power plant fly ash were evaluated at that time as stabilization agents, in view of their hydration properties. On-site soils were used as a bulking agent in combination with these stabilization materials. The results of these evaluations are given in Table 2-1.

A "worst case" leachate was then prepared by crushing stabilized wastes and subjecting them to the TDWR leachate determination, with the results (mixture ratios were not identified in the report) shown in Table 2-2.

Laboratory tests were conducted to evaluate the properties of the wastes solidified with the most efficient admix agents. The following results were obtained:

1985 Geotechnical Testing Data

	Additives	
	Soil and Fly Ash	Soil and Quick Lime
Permeability (cm/sec)	4.8×10^{-8}	5.7×10^{-7}
Density (lb/ft^3)	109	93

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Table 2-1

1985 Stabilized Waste Strength Data

Stabilization Testing

Sample	1	2	3	4	5	6
Blend (Volume units)						
Sludge	1	1	1	1	1	1
Soil	1	1	1	1	1	1
Fly Ash	1	0.67	0.5	-	-	-
Quick Lime	-	-	-	0.2	0.15	0.1
Shear Strength (psi)						
3-Day	2	0.7	0.5	10	4	1.4
21-Day	17	7	10	28	17	12
Compressive Strength[1](psi)						
3-Day	10	3.5	2.5	50	20	7
21-Day	85	3.5	50	140	85	60

NOTE:
[1] Five times shear strength.

011145

TABLE 2-2

1985 CHEMICAL ANALYSIS DATA
[illegible]ization Testing
Usin[illegible]R Leachate Test [a]

Parameter	Fly Ash Admix	Quick Lime Admix
pH	7.8	11.1
Specific Conductance (umhos/cm)	1220	4140
Chloride (mg/l)	525	255
Sulfate (mg/l)	27	127
Chromium (mg/l)	0.03	<0.01
Lead (mg/l)	<0.01	<0.01
Zinc (mg/l)	0.01	0.02
Total Organic Carbon (mg/l)	498	932
Oil and Grease (mg/l)	162	246
Phenolics (mg/l)	28.6	37.5
Total Organic Chlorides (mg/l)	0.93	1.16
Polychlorinated Biphenyls (mg/l)	<.050	<.050

011146

[a] Texas Department of Water Resource Industrial Solid Waste Management Technical Guideline No.1, Revised 5-11-82 (Subsequently the Texas Water Commission Industrial Solid Waste Management Technical Guideline No.1, Revised 12-6-85). 250 grams of material is leached in 1 liter of deionized or distilled water for seven days.

These tests also showed that the stabilized pond sludge will shrink in volume and produce an equal volume of free liquid. A subsequent round of tests showed that admixes with soil eliminate shrinkage and free water production.

2.5 Test Methods

The more recent testing focused on the effective reduction of mobility and toxicity of the pond sludge constituents. An initial series of tests of admixes without soil showed effective reduction of mobility and toxicity.

Stabilization was attempted using fly ash and proprietary stabilization methods. ERM-Southwest tested simple fly ash mixing (using fly ash from the HL&P Parish plant in Houston, Texas) and the following three vendors were asked to test their own proprietary technology:

1. ENRECO, Inc. in Amarillo, Texas
2. SOLIDITECH, Inc. in Houston, Texas
3. Chemfix Technologies, Inc. in Metairie, Louisiana

The vendors were asked to stabilize samples at 10-fold, 100-fold and 1000-fold reduction in leachate concentration of lead, where the choice of lead as a target metal was arbitrary. Control samples were not produced to evaluate volatilization of organics during mixing and curing.

The chemical laboratory used was ENSECO Rocky Mountain Analytical Laboratory in Arvada, Colorado. They tested for HSL (hazardous substance list) metals in a TCLP (toxicity characteristic leaching procedure) leachate. Methods for metals and organic compounds are primarily derived from three sources of EPA methods: 1) the methods promulgated in 40 CFR 136 for priority pollutants; 2) the methods published in SW-846; and 3) methods developed by the EPA-EMSL/LV for Superfund investigations, as well as several documents published by the EPA and ENESCO-Rocky Mountain Analytical Laboratory in 1984 and 1985.

The geotechnical laboratory used was McClelland Engineers in Houston, Texas. Sample molds were prepared by the vendors per ASTM 1632-79. Permeability was tested per EM-1110-2-1906 Appendix VIII. As in previous testing, shear strength was measured as compressive strength. Shear strength was measured rotating a vane/spring testing tool at 6 to 12 degrees per minute.

2.6 Stabilization System

ERM-Southwest prepared fly ash stabilized samples for testing using fly ash from HL&P's Parish Plant in Houston, Texas. Ash was added to a sludge sample until it was estimated that the mixture became stiff enough to be easily handled by earthmoving equipment. This proved to be a mixture of 3:2.5 (ash:sludge by weight). While it is not believed that the use of fly ash alone to stabilize wastes is proprietary, the most cost-effective methods for obtaining a uniform mixture in the field may be proprietary.

SOLIDITECH's proprietary Urritech solidification process uses the combination of a proprietary chemical catalyst and a pozzolanic material such as fly ash or kiln dust. The process works by cross-linking organic and inorganic particles in the mixture through a five-phase cementation process. Compressive strengths in excess of 4000 psi (concrete typically ranges from 2000 to 6000 psi) have been achieved in organic sludges. This process has, the vendor says, successfully been used to solidify (the vendor's meaning of that term is unclear) API separator oils and PCBs, as well as other organic wastes. The vendor determined that this process would cost between $60 and $150 per yd^3 for in-situ treatment, depending on further testing. In later discussions, the vendor said that the volume of the treated waste increased 105% over the untreated waste.

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ENRECO is a stabilization contractor who utilizes a variety of stabilization agents and mixing means, but who markets a proprietary injector/mixer system for in-situ waste stabilization. By this system, ENRECO treats a waste impoundment perimeter using the injector/mixer system installed on a large backhoe, then works from the stabilized material to treat a new, smaller perimeter. Each perimeter is used as a platform to treat the next until the entire impoundment is treated. The vendor estimated that the cost of stabilization would be between $45 and $65 per yd^3 -- a relatively high cost because they found that the pond sludge was "difficult to set", i.e. common stabilization mixes were not sufficiently stable. This cost is independent of the different stabilizing agents used to produce the samples for this study.

After 15 trials, ENRECO submitted the following samples:

<u>ENRECO Sample No.</u>	1/10	1/100	1/1000
<u>ERM-Southwest Sample No.</u>	TREAT-21	TREAT-22	TREAT-23
Sludge (g)	1095	1095	1095
Rice Hull Ash (g)	550	550	550
Portland Cement (g)		342	342
Sodium Carbonate (g)			100

The sample numbers reflect the direction to the vendors to reduce leachate lead concentrations by a factor of 10, 100 and 1,000. That proved to be an ineffective direction because the leachable lead concentrations were insignificant.

Later, the vendor submitted data for 13 additional trials utilizing soil with Portland cement or fly ash as admix.

Chemfix Technologies, Inc. could not submit fixed samples to the chemical laboratory in time for scheduled testing.

2.7 Laboratory Testing Results

Chemical laboratory results are summarized in Tables 2-3 and 2-4. Geotechnical laboratory results (Attachment 1) are duplicated in Table 2-5. Note that SOLIDITECH, Inc. did not have sufficient waste sample volume to generate geotechnical testing samples. ENRECO's second set of 13 test runs is summarized in Table 2-6.

Volatile organics data summarized in Table 2-3 include: 1) analysis of the untreated sludge as a direct analysis and as a TCLP leachate and 2) analysis of the treated sludge as a TCLP leachate. Chemical analysis of organic constituents was limited to volatile organics because it is widely known that nonvolatile organics can be effectively immobilized by stabilization. Nine volatile organic constituents were detected in the TCLP leachate of the untreated waste. Generally, stabilization reduced the TCLP leachate concentrations by 50%. Note, however, that the SOLIDITECH stabilized waste is ND (not detected) for benzene.

Metals data summarized in Table 2-4 include: 1) analysis of the untreated sludge as a direct analysis and as a TCLP leachate and 2) analysis of the treated sludge as a TCLP leachate. The data show that stabilization generally had little effect on the leachability of metals as measured by the TCLP. Lead was undetectable in both treated and untreated leachates. Arsenic, on the other hand, actually increased in concentration when the waste was stabilized.

Geotechnical testing data duplicated in Table 2-5 shows that fly ash stabilization yields a very low permeability, but has poor structural strength relative to stabilization by vendors. All stabilization treatment without soil appears to have freed liquids from the waste, creating the need for drainage, collection, transport, wastewater treatment discharge. Compressive strength (based on shear strength tests) does not meet the engineering

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Table 2-3

Chemical Analysis Data Summary
Volatile Organics - Stabilization Testing

	mg/kg	TCLP Leachate, mg/l			
	Pond Sludge		Treated Pond Sludge		
Detected HSL Volatiles	Raw	Raw Leachate	Flyash	SOLIDI-TECH	ENRECO 1/100
ERM-Southwest Field No.	INCIN-0	TREAT-0	TREAT-32	TREAT-61	TREAT-22
RMAL Lab No.	63942-2	64298-	64298-2	64435-1	64417-2
Acetone	ND [b]	1.2	0 59	0.55	ND
Benzene	170	2.9	1.1	ND	0 91
2-Butanone	ND	2	0.92	0.53	0.98
Chlorobenzene	ND	0.01	0.15	ND	0.2
1,1-Dichloroethane	ND	0.028	ND	ND	ND
1,2-Dichloropropane	ND	0.049	ND	ND	ND
Ethyl benzene	580	1.4	1.1	0.48	1.1
2-Hexanone	ND	0.45	0.14	ND	ND
4-Methyl-2-pentanone	ND	2.5	0.33	0.19	1.5
Styrene	340	1.2	0.95	0.47	2.8
Tetrachloroethene	51	0.11	0.074	ND	ND
Toluene	700	5	3.1	0.48	2 8
trans-1,2-Dichloroethene	ND	0.045	ND	ND	ND
Trichloroethene	ND	0.12	0 072	ND	ND
Total Xylenes	1600	4.3	3.4	1.7	3

NOTES:

[a] The use of the TCLP does not constitute acceptance of this test method.
[b] ND = Not detected.

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TABLE 2-4
Chemical Analysis Data Summary
Metals - Stabilization Testing

HSL Metals	mg/kg Pond Sludge: Raw	mg/kg Pond Sludge: Raw Leachate	TCLP Leachate, mg/l [a] Treated Pond Sludge: Flyash	ENRECO 1/10	ENRECO 1/100	ENRECO 1/1000
ERM-Southwest Field No.	INCIN-0	TREAT-0	TREAT-32	TREAT-21	TREAT-22	TREAT-23
RMAL Lab No.	63942-2	64298-1	64298-2	64417-1	64417-2	64417-3
Aluminum	2300	0.7	ND [b]	ND	ND	ND
Antimony	12	ND	ND	ND	ND	ND
Arsenic		0.064	0.084	ND	0.07	0.18
Barium	820	0.9	0.3	0.4	1.5	0.6
Beryllium	ND	ND	ND	ND	ND	ND
Cadmium	2.7	ND	ND	ND	ND	ND
Calcium	5200	92	790	150	1580	790
Chromium	160	0.03	ND	ND	ND	0.03
Cobalt	3	0.05	ND	0.03	ND	ND
Copper	130	ND	ND	ND	ND	ND
Iron	4300	18	ND	0.7	ND	ND
Lead	310	ND	ND	ND	ND	ND
Magnesium	920	19	53	44	22	12
Manganese	71	0.88	0.16	8.5	0.02	0.01
Mercury		ND	ND	ND	ND	ND
Nickel	69	0.33	ND	0.25	ND	ND
Potassium	ND	ND	ND	100	60	70
Selenium		0.004	0.05	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND
Sodium	2200	ND	ND	ND	91	ND
Thallium		ND	ND	ND	ND	ND
Tin	ND	ND	ND	ND	ND	ND
Vanadium	25	0.07	0.39	0.04	0.23	0.76
Zinc	970	0.7	ND	0.8	ND	ND

NOTES:
[a] The use of the TCLP does not constitute acceptance of this test method.
[b] ND = Not Detected

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TABLE 2-5

Geotechnical Analysis Data
Stabilization Testing

HSL Metals	Flyash	ENRECO 1/10	ENRECO 1/100	ENRECO 1/1000
ERM-Southwest Field No.	TREAT-32	TREAT-21	TREAT-22	TREAT-23
Physical Description	very soft tended to slump		stiff, very friable, ends twice the consistancy of the middle	
Observed shrinkage [a] (%)	5	10	1	1
Water content (%)	30	54	35	35
Unit dry weight (lb/ft3)	92	53	65	69
Permeability (cm/sec)	1.9E-7	1.2E-5	5.0E-5	1.2E-5
Shear strength (lb/ft2)	20	60	420	2250
Compressive Strength [b] (lb/in2)	0.7	2	15	78
Cure Time (days)	12	40	40	40

NOTES:

[a] Shrinkages shown are longitudinal. The void caused by shrinkage was filled with a "dark blackish green liquid about the consistency of water". TREAT-23 alone was also noted to have shrunk laterally (by about 2.5%).

[b] Five times shear strength (different units also)

Table 2-6

Vendor Test Data Summary [1]

Stabilization Testing

Vendor Sample Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Blend													
Sludge (g)	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140
Soil (g, wet wt.) [2]	3760	3760	3760	3760	1710	1710	1710	1710	910	910	910	910	3760
Portland Cement (g)	11	23	---	---	23	46	---	---	23	46	---	---	---
Fly Ash (g)	---	---	23	46	---	---	46	91	---	--	46	91	
UC Strength [3]													
1 Days (psi)	39	63	47	63	13	21	15	40	---	<1	<1	1	4
2 Days (psi)	53	---	59	>63	[illegible]	31	28	>63	---	<1	<1	1	8
7 Days (psi)	51	---	63	63	[illegible]	33	39	>63	<1	<1	3	20	13
Volume Increase % [4]	13	18	6	30	5	15	12	36	---	---	---	---	---
Wet Density (lb/ft3) [5]	93	95	106	98	99	103	105	108	---	---	---	---	---
Free Water [6]	no	no	no	no	no	no	no	no	yes	yes	yes	yes	---

NOTES:
[1] Data submitted by ENRECO. Samples were prepared on December 17, 1987 using admix designs of their selections
[2] Soil supplied from SDS site near MW-40 (south of Clark Lake near road).
[3] Unconfined compressive strength measured with a pocket penetrometer.
[4] Changes in volume measured after mixing soil with sludge
[5] Time after mixing was not identified by vendor.
[6] Verbal communication with vendor, sample 13 not discussed
General - Meaning of "-" not identified by vendor.

criteria of 15 psi until Portland cement is added (Table 2-5) or until soil plus fly ash or Portland cement is added (Table 2-6).

2.8 Preliminary Stabilization Concept Design

For purposes of developing costs for stabilization alternatives, a stabilization concept is proposed, based on the preceding data. Note that this concept is very preliminary and may be further developed to produce a more cost-effective remediation.

Stabilization, as proposed, will feature in-situ mixing with a rice hull ash and Portland cement admix blended with an injector/mixer. The stabilized sludge will be a 1:0.5:0.3 mixture (sludge weight:rice hull ash:Portland cement weight), and will result in a volume increase of 20%. This blend is based on sample number 1/100 in Section 2.6 and volume increase is based on sample numbers 1 through 8 on Table 2-6.

2.9 Future Stabilization Testing

The Phase 1 bench scale study was preliminary in nature, in that it focused on confirming the viability of stabilization of the pond sludge, and on determining the cost of stabilization for comparison with other technologies. Additional testing is recommended, as stabilization has proven to be cost-effective both as a separate alternative and as supplemental treatment to other alternatives. A Phase 2 bench scale study is needed to more accurately define design parameters, to establish a leachate performance criterion, and to identify candidate stabilization blends. A Phase 3 field scale study may then be needed to confirm the Phase 2 results, because bench scale testing of stabilization does not adequately quantify the problems of full scale blending and mixing.

3.1 General

A process for the separation of the components of a solution using the unequal distribution of the components between immiscible liquids is called solvent extraction, or more accurately liquid-liquid extraction. The solution is mixed with a suitable incompletely miscible liquid which preferentially attracts one of the components. In the two systems evaluated, the B.E.S.T. process uses an aliphatic amine to attract water, and the CF Systems process uses propane to attract organics. The remainder of the systems are focused on separating the miscible liquid from the attracted water or organics and on washing the remaining solids.

Figure 3-1 schematically illustrates the B.E.S.T. process. In the cold stage, sludges or soils are mixed with amine at low temperature. The mixture ratio is a function of feed composition, but is often on the order of two parts amine for each part of sludge. At this temperature, liquid fractions are soluble and suspensions and emulsions are virtually eliminated. The solids fraction becomes readily separable and can be removed by filter or centrifuge and dried. Since the amine is alkaline, heavy metals in the sludge are converted to hydrated oxides which precipitate and exit the process with the solids fraction. In the hot stage, the single phase amine/water/oil fraction is heated to form an amine/oil phase and water phase, which are then separated by decanting. The final steps in this process involve solvent recovery, generally by thermal means.

Figure 3-2 schematically illustrates the CF Systems process, and is self-explanatory. Note that solids washing is not shown.

Solvent extraction is promoted by its vendors as pretreatment for incineration or chemical dechlorination. As pretreatment for incineration it allows a very homogeneous feed to a liquids incinerator instead of a large rotary kiln. As pretreatment for chemical dechlorination it would remove the solid matrix that interferes with the effectiveness of that process, and results in a fuel that could potentially be reused.

3.2 Objective

The objective of solvent extraction testing is to determine if treatment of the pond sludge with this process is feasible for the SDS site and if so to develop a conceptual design for purposes of determining the cost of solvent extraction alternatives.

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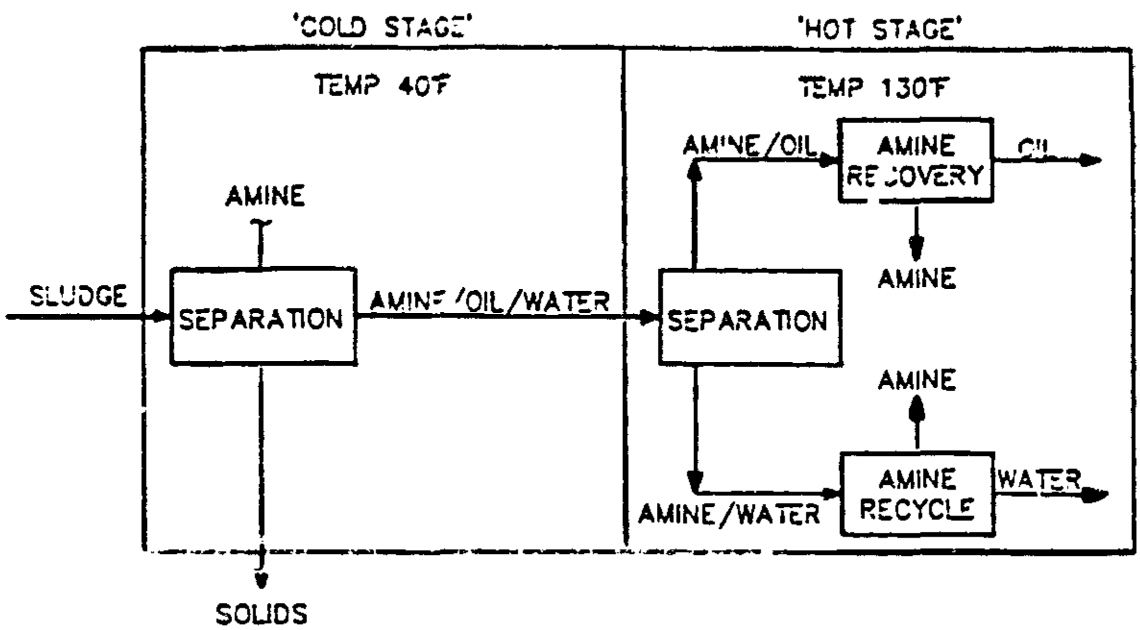


ERM-Southwest, inc.
HOUSTON, TEXAS

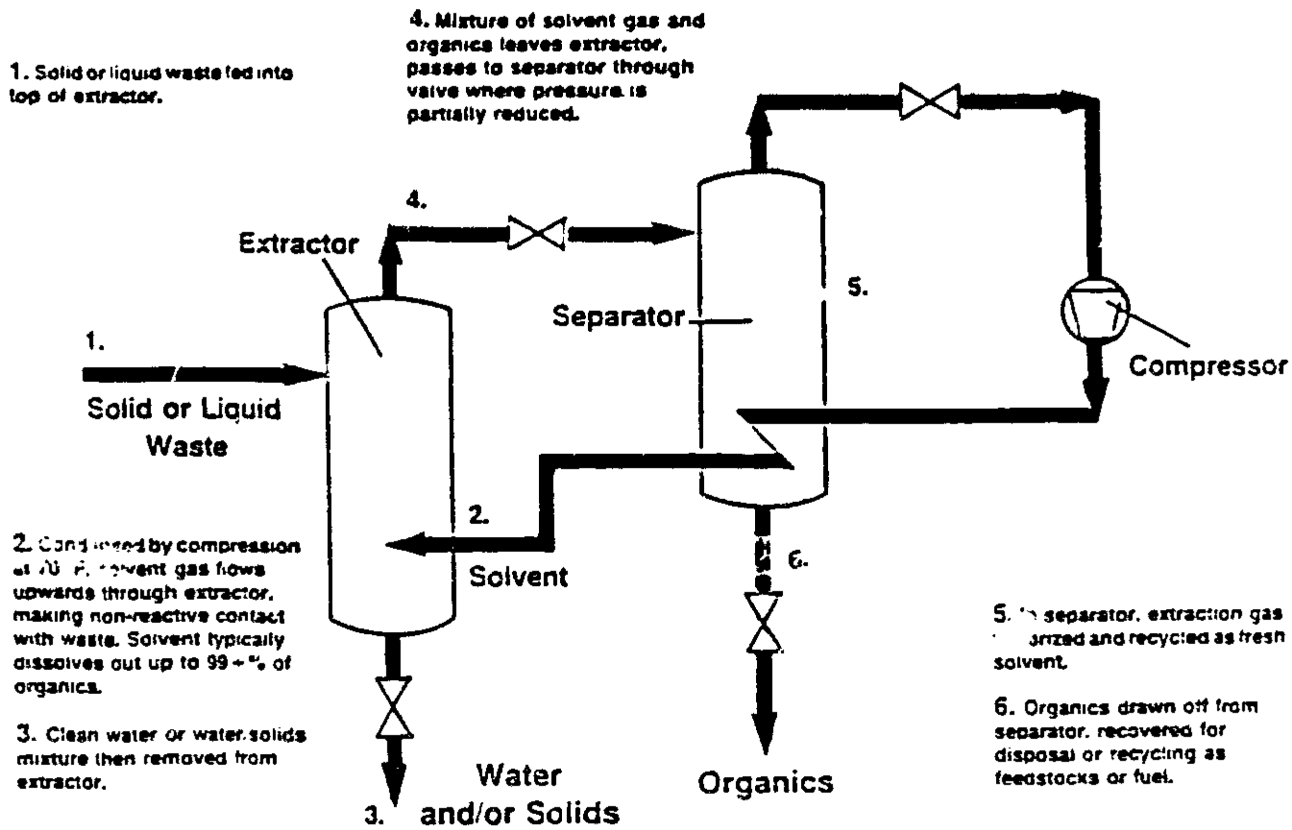
1/21/88	W.O. NO. 9101B023

FIGURE 3-1
B.E.S.T. PROCESS

SHERIDAN DISPOSAL SERVICES
HEMPSTEAD, TEXAS

Simplified Flow Chart

Here is the CF Systems unit operating cycle, for extracting and separating organics from liquid or solid waste:



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ERM-Southwest, inc. HOUSTON, TEXAS		FIGURE 3-2 CF SYSTEM PROCESS SHERIDAN DISPOSAL SERVICES HEMPSTEAD, TEXAS
1/21/88	W.O. NO. 9101B024	

3.3 Test Methods

The following two vendors were asked to test their proprietary technology:

1. Resources Conservation Co., in Bellevue, Washington, which markets the previously mentioned B.E.S.T. process.

2. CF Systems Corporation in Cambridge, Massachusetts, which markets the other previously mentioned process under their own name.

The vendors were asked to segregate the pond sludge into three residual fractions as follows:

Residual Oil	- to undergo further treatment.
Residual Water	- clean enough for biological treatment and discharge.
Residual Solids	- dry, free of organics, acceptable for direct landfilling without further treatment.

Because of laboratory constraints on handling PCBs, CF Systems was unable to treat the wastes in a timely manner. The B.E.S.T. report is Attachment 2 of this report.

The chemical laboratory used to test the B.E.S.T. residuals was ENSECO Rocky Mountain Analytical Laboratory in Arvada, Colorado. To determine if the fractions met the above criteria, they were tested as follows:

Residual Oil	- tested for PCBs to enable a materials balance for those compounds.
Residual Water	- tested for PCBs and oil and grease to enable a materials balance and determine if other organics were present.
Residual Solids	- tested for PCBs and oil and grease to enable a materials balance and determine if other organics were present. Also tested for HSL organics and metals in a TCLP leachate to confirm that further treatment is not needed.

3.4 Laboratory Testing Results

Chemical laboratory results are summarized in Tables 3-1, 3-2 and 3-3 (Attachment 3).

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Table 3-1

Chemical Analysis Data Summary

PCBs - Solvent Extraction Testing

PCBs	Pond Sludge mg/kg	Treated Pond Sludge Residual Oil mg/kg	Residual Water mg/l	Residual Solid mg/kg
ERM-Southwest Field No.	INCIN-0	TREAT-41	TREAT-42	TREAT-43
RMAL Lab No	63942-2	64458-3	64458-2	64458-1
Aroclor 1016	55	<3.2	< 0044	<.08
Aroclor 1221	<6.4	<3.2	<.0044	<.08
Aroclor 1232	<6.4	<3.2	<.0044	0.26
Aroclor 1242	<6.4	190	<.0044	<.08
Aroclor 1248	<6.4	<3.2	<.0044	<.08
Aroclor 1254	<13	<6.4	<.034	<.16
Aroclor 1260	13	23	<.034	< 16
Oil & Grease	NT	NT	680	1500

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Table 3-2

Chemical Analysis Data Summary

HSL Organics - Solvent Extraction Testing

Detected HSL Volatiles and Semivolatiles	mg/kg Pond Sludge Raw	TCLP Leachate, mg/l [a] Pond Sludge Raw Leachate	Treatment Residual Solid
ERM-Southwest Field No.	INCIN-0	TREAT-0	TREAT-43
RMAL Lab No.	63942-2	64298-1	64458-1
Acetone	ND [b]	1.2	0.2
Benzene	170	2.9	ND
2-Butanone	ND	2	ND
Chlorobenzene	ND	0.31	ND
1,1-Dichloroethane	ND	0.028	ND
1,2-Dichloropropane	ND	0.049	ND
Ethyl benzene	580	1.4	ND
2-Hexanone	ND	0.45	ND
4-Methyl-2-pentanone	ND	2.5	ND
Styrene	340	1.2	ND
Tetrachloroethene	51	0.11	ND
Toluene	700	5	ND
trans-1,2-Dichloroethene	ND	0.045	ND
Trichloroethene	ND	0.12	ND
Total Xylenes	1600	4.3	ND
4-Methylphenol	850	NT [c]	1.3

NOTES:

[a] The use of the TCLP does not constitute acceptance of this test method

[b] ND = Not Detected

[c] NT = Not Tested

011160

D425

Table 3-3

Chemical Analysis Data Summary

Metals - Solvent Extraction Testing

HSL Metals	Pond Sludge mg/kg Raw	Pond Sludge TCLP Leachate mg/l [a] Raw Leachate	Treatment Residual Solid
ERM-Southwest Field No.	INCIN-0	TREAT-0	TREAT-43
RMAL Lab No.	63942-2	64298-1	64458-1
Aluminum	2300	0.7	4.6
Antimony	12	ND [b]	0.8
Arsenic		0.064	ND
Barium	820	0.9	2
Beryllium	ND	ND	ND
Cadmium	2.7	ND	0.03
Calcium	5200	92	230
Chromium	160	0.03	2.6
Cobalt	3	0.05	0.37
Copper	130	ND	1.9
Iron	4300	18	17
Lead	310	ND	0.6
Magnesium	920	19	90
Manganese	71	0.88	2.1
Mercury		ND	0.017
Nickel	69	0.33	3.1
Potassium	ND	ND	40
Selenium		0.004	ND
Silver	ND	ND	ND
Sodium	2200	ND	3590
Thallium		ND	ND
Tin	ND	ND	ND
Vanadium	25	0.07	0.66
Zinc	970	0.7	19

NOTES:
[a] The use of the TCLP does not constitute acceptance of this test method.

[b] ND = Not Detected

011161

The PCBs concentrated in the residual oil except that 0.26 mg/kg, a negligible amount, remained with the solids. Table 3-1 shows that the PCB concentration increased over three-fold on a dry weight basis when water and solids were removed. The same table shows 680 mg/l oil and grease remaining in the residual water. Leachate testing shows that solids may present a problem. Table 3-2 shows that some solvents can be leached from the residual solids. Table 3-3 however, shows that metals in the residual solids are relatively mobile. TCLP chromium, lead and mercury are one-half to one-tenth levels regulated as 40 CFR 261 Subpart C Characteristic Hazardous Wastes. Contrary to the claims of the vendor, concentrations of those constituents are sufficiently high to preclude landfilling without controls.

3.5 Design Implications

Incineration gains important benefits from solvent extraction as feed preparation. The oil residuals are homogeneous and presumably could be fluidized with heat and be atomized for incineration. Alternately, the oil residuals can be hauled to a chemical dechlorination facility for treatment and reuse. Residual water has to be pretreated before being treated with other site wastewaters to lower the pH and remove high levels of oil and grease. Residual solids must be monitored and perhaps treated. Finally, the vendor's report mentions an unsolved problem with an emulsion buildup in the decantation step.

0111162

4 - CONCLUSIONS AND RECOMMENDATION

4.1 Conclusions

1. Stabilization appears to be a feasible technology for the immobilization of organic and inorganic waste constituents.

2. Stabilization is known to effectively mobilize heavy organics, and further testing is underway to confirm that light organics are effectively immobilized as well.

3. Stabilized material should achieve an unconfined compressive strength of at least 15 psi in 24 hours.

4. Stabilization admixes without soil cause shrinkage and the release of free water.

5. Stabilization increases the volume of the waste being treated by 15 to 100%, depending on whether soil is added.

6. Solvent extraction appears to be a feasible technology being developed to segregate waste into oil, water and solids fractions for further treatment.

7. Solvent extraction water residuals require treatment, and solids residuals require monitoring and perhaps treatment.

4.2 Recommendation

1. Utilize the preliminary basis of design developed in Section 2 and the vendor unit costs for estimating the cost of stabilization alternatives.

2. Perform Phase 2 bench scale stabilization of pond sludge, affected soil and biotreatment solids to better define design parameters, establish a leachate performance criterion, and identify candidate stabilization blends.

3. Use B.E.S.T. data to estimate the cost of the solvent extraction alternative.

ATTACHMENT 1

Geotechnical Laboratory Report

0111164

McClelland engineers

P O. Box 740010. Houston. Texas 77274. Tel. 713/772-3700. Telex 762447

October 5, 1987

Mr. Chris Tanner
ERM-Southwest, Inc.
1600 Memorial Drive, Suite 200
Houston, Texas 77079-4006

Attention: Chris Tanner

Submitted here are the laboratory test results for permeability and shear strength measurements. The tests were performed on one sample supplied by ERM Southwest and three samples supplied by ERRECO.

Prior to testing it was observed that the ERM sample was approximately 1/4" shorter and 1/16" less in diameter than the internal dimensions of the molding tube. This void was filled with a dark blackish green liquid about the consistency of water. The sample was very soft and tended to slump when removed from the mold.

The ERRECO samples were the same diameter as the mold, but shorter. Sample 1/10 was about 1/2" shorter, Sample 1/100 and 1/1000 were about 1/16" shorter than the mold. All three samples had less then 5 ml of free liquid present. When sample 1/10 was removed from the mold, it's appearance was similar to the ERM sample. Samples 1/100 and 1/1000 however, were more stiff, but very friable, and the ends of the samples were approximately twice the consistency as the middle portion. The vane shear test was performed on the middle portion of the samples.

We appreciate the opportunity to work with you on this project. If you have any questions about the test data please call.

Sincerely,
McClelland Engineers, Inc.

Kenneth W Hill

Kenneth W. Hill
Laboratory Supervisor

Enclosure

KWH/sc

011165

MINIATURE VANE

1. SCOPE: Described within this section is the standard procedure of preparing test specimens, conducting the miniature vane test, computing and presenting the test data.

2. REFERENCE

   Unit Training Guide on Miniature Vane
   McClelland Engineers, Inc., Houston, TX, 1979

3. TEST EQUIPMENT

   The miniature vane shearing device consists of a vane/spring rotation apparatus, which is powered manually or electrically and shall rotate the top of the spring at a rate of 6-12 degrees per minute. This apparatus shall have an indicator, which displays the rotation of the spring in degrees. The vane shall consist of a four-bladed vane that may vary from 1/2" X 1/2" to 1" by 1". A balance sensitive to 0.01 g will be used for weighing moisture specimens.

4. SAMPLE PREPARATION

   Specimens should have a diameter sufficient to allow 1/2 inch clearance between all points on the circumference of the shearing surface and the outer edge of the sample.
   Undisturbed Specimens - Test may be run in the tube for thin-walled tube samples eliminating the need for extrusion.
   Remolded Specimens - The remolded material is compacted into a mold of circular cross section having dimensions meeting the requirements stated earlier.

5. PROCEDURE

   Using the torvane, the soil strength is estimated in order to select the proper vane and vane spring. The end of the sample

01166

where the vane will be inserted should be trimmed flat and perpendicular with the wall of the tube. The tube containing the sample is then clamped firmly in the apparatus. The vane is inserted in the sample to a depth equal to twice the height of the vane and the initial reading is taken. Rotation of the vane shall be initiated either manually or mechanically so as to rotate the top of the spring approximately 10°/min. The vane is allowed to rotate until failure occurs and the final reading is recorded. Spring rotation, however, may not exceed 180°. (Vane springs are calibrated only to 180°, therefore; when 180° is exceeded, the spring could become overstressed which would cause invalid results.) The vane is removed and a representative sample of the specimen is secured to determine the moisture content.

Calculations are performed and the results and data are entered on Form 16C-2.5 (1979). Test computation are made and the results reported as specified in ASTM D 257-72. Computations, graphical plotting and interpretations shall be independently checked.

Summary of Test Results
Chemical Fixation Study

Job No. 0187-0301
Date: Oct. 1, 1987

Sample Identification	Water Content (%)	Unit Dry Weight (pcf)	Permeability (cm/sec)	Minature Vane Shear Strength (KSF)
ERM	29	92	1.9×10^{-7}	-
	30	-	-	0.02
ERRECO 1/10	54	53	1.2×10^{-5}	-
	54	-	-	0.06
1/100	36	65	5.0×10^{-5}	-
	35	-	-	0.42
1/1000	31	69	1.2×10^{-5}	-
	36	-	-	2.25

ATTACHMENT 2

Vendor Report - Resources Conservation Co.

011169

B.E.S.T.™ GLASSWARE TEST REPORT

for

ERM Southwest/Sheridan Site Sludge

011170

Prepared by

Resources Conservation Company
3101 N. E. Northup Way
Bellevue, Washington 98004

October 12, 1987

B.E.S.T. Glassware Test Report

for

ERM Southwest/Sheridan Site Sludge

Introduction

A sample of waste material from a waste impoundment pond at a site near Sheridan, Texas was submitted to the RCC analytical lab for a B.E.S.T. glassware simulation. The sample was received on 7/30/87 in a five gallon plastic bucket. The sample had partially separated during shipment; there was an oily water layer on top and a semi-solid oily sludge had settled to the bottom. Although the sample contained some lumps of solids, these could be easily broken down to smaller sizes and screening of the sample to ensure small particle size was not required. After mixing the contents of the bucket to achieve homogeneity, an aliquot was removed for further testing.

011171

Compositional Analysis

The material was analyzed for Total Solids at 105°C to determine its volatile (i.e., water) and non-volatile fractions (i.e., solids + oil/heavy organics) at 105°C.

The dried sludge sample derived from the Total Solids determination was then placed into a Soxhlet extractor and extracted with methylene chloride overnight to gravimetrically determine oil content. The solids were determined by difference. The results of these analyses were as follows :

Analyte	Result
Oil %	35.
Water %	44.
Solids %	21.
PCB's	106. ppm

In addition to the above, the heavy metals composition of the sludge was determined:

Raw Sludge Metals Composition

Analyte	Result, mg/Kg
Aluminum	5,300.
Arsenic	23.
Barium	2.2
Boron	24.
Cadmium	3.4
Chromium	170.
Copper	240.
Iron	5,800.
Lead	320.
Manganese	76.
Nickel	75.
Zinc	930.
Strontium	31.
Phosphorus	660.
Selenium	32.
Silver	<5.
Mercury	<1.

011172

Triethylamine Compatibility Test

Triethylamine (TEA) is a compound with a unique chemical structure. The geometry of the structure is tetrahedral, meaning that the Nitrogen atom is at the center of a pyramid. The four points of the pyramid structure are occupied by three ethyl functional groups and one Pi electron cloud. This structure gives TEA a dual polarity characteristic. The ethyl groups are essentially nonpolar, the Pi electron cloud is polar. This dual polarity is the reason TEA works so well in extracting sludges and emulsions that have appreciable water content. However, the electron pair of the Pi orbital can also react with certain types of materials. In order to determine if this will occur with a sample, a compatibility test is performed. This involves mixing of the sample with TEA and making observations as to the heat of solution and any other visual signs of reaction.

A 7.95 gm portion of mixed sludge at 67 degrees F. was mixed with 100 mls of TEA that had been chilled to 18 degrees F.. The initial temperature of the mixture was 41 degrees F. indicating that no excessive heat of solution or reaction would be encountered. The TEA quickly turned brown/black in color indicating that the oils present in the sample are readily soluble in TEA.

Based on the favorable results of this preliminary test, it was decided that the glassware B.E.S.T. simulation should proceed.

Sludge pH Adjustment

TEA can be ionized at low pH to triethylammonium salts which cannot be removed from the products. The basic nature of the TEA will buffer the pH of the sample to approximately nine. The TEA spent in the pH buffering will be lost as a TEA salt. In order to efficiently recover the TEA from the separated sludge products (oil, water, and solids) the pH of the sample is adjusted to about 12.

A 12.3 gm portion of sludge was mixed with 100 mls of water. The pH of this mixture was measured to be 6.4, indicating that caustic would need to be added. Incremental portions of 50 % caustic were added to bring the sample pH to about 12.0. The average amount of caustic that was required to perform this pH adjustment was equivalent to 65. mls of 50% caustic per kilogram of sludge. Exact caustic requirements for full scale treatment of this material would have to be determined in a separate study.

Sludge Extraction

Based on the caustic dosage information obtained previously, a 600 gram portion of the sludge sample was pH adjusted by adding 39. mls of 50 % caustic prior to TEA extraction. After pH adjustment, the sludge was chilled to 40°F and then was added to three litres of chilled TEA. Mixing was performed by an air driven prop mixer in an open top beaker. The mixer was able to induce adequate mixing in the beaker, indicating that no mixing complications should arise during full-scale operations. As expected, the solvent became dark colored indicating that oil extraction was taking place. After a residence time of thirty minutes the mixing was stopped. The mixture's solids fraction was primarily composed of two types of particulate solids; a layer (approximately 10%) of finely divided light fluffy solids, and a heavier layer of gritty solids of much larger particle size. The particulate solids were observed to readily settle to the bottom of the beaker immediately when mixing ceased. The fines remained in suspension.

The cool T.E.A./sludge mixture was then centrifuged in a floor mounted centrifuge to remove solids.

3370 mls of centrate (specific gravity @40°F= 0.75) and wet solids (240. gm) were obtained after centrifugation.

An additional wash step employing similar conditions to the first extraction was carried out to further remove residual Oil and Grease from the wet solids recovered during the first extraction.

After the second TEA/centrifugation step, 3000 mls of centrate (spec. gravity @40°F= 0.72) and 254. grams of wet solids were obtained. The wet, washed solids were dried at 105°C to evaporate TEA. The dried solids were labeled Product Solids.

Chemical analysis of the Product Solids yielded the following results:

Product Solids Analysis

Analyte	Result
Residual Triethylamine	370. ppm
Residual Oil and Grease (freon)	1.2 %
Residual PCB's	0.75
Total Metals Analysis;	
Aluminum	26,000.
Arsenic	150.
Barium	54.
Boron	100.
Cadmium	16.
Chromium	800.
Copper	670.
Iron	26,000.
Lead	1,600.
Manganese	350.
Nickel	280.
Zinc	4,300.
Strontium	190.
Phosphorus	3,400.
Selenium	140.
Mercury	<10.
Silver	<1.

Product Solids leachability, as indicated by the EP Toxicity extraction test, showed the following results for the leachate:

Analyte	Result, mg/L
Arsenic	1.3
Barium	17.
Cadmium	0.06
Chromium	4.0
Lead	3.3
Selenium	1.2
Silver	<0.02
Nickel	5.9
Copper	10.
Zinc	25.
Mercury	<.1

011174

Toxicity Characteristic Leaching Procedure (TCLP) extract metals analysis (mg/l);

Analyte	Result, mg/L
Arsenic	.96
Barium	14.
Cadmium	.06
Chromium	3.1
Copper	9.5
Lead	3.9
Nickel	4.3
Zinc	22.
Selenium	.9
Mercury	<.1
Silver	<.02

011175

Decantation of TEA/Oil from Water

The centrate from the initial TEA/Sludge mixing was heated to 140 F. to effect the separation of the aqueous and organic fractions. The decantation was performed in a four-litre separatory funnel immersed in a heated water bath to control thermal loss. The centrate was allowed one half hour of quiescent time at the elevated temperature prior to decantation. Separation occurred readily, but the presence of an emulsion 'rag' layer was noted which did not subside under the conditions of the simulation decantation.

Observations indicated that maximum separation was achieved in the first ten minutes of the decantation. The decanted centrate was separated by draining off the lower (water) layer. A water layer volume of 203 mls (spec. gravity @140°F=.93) was recovered.

Water TEA Stripping

Removal of TEA from the decanted water fraction was accomplished by boiling the water at an elevated pH (>11.5). The elevated pH is necessary to ensure efficient removal of TEA which needs to be in the molecular form. After TEA removal, the water volume was reconstituted to its original volume (203 mls) using deionized water and collected as the Product Water.

Product Water Analysis(untreated)

Analyte	Result, mg/L
Residual TEA	21.
Final pH	11.8
Oil and Grease	13,000. *
Total Dissolved Solids	189,000.
Aluminum	310.
Arsenic	0.8
Barium	0.03
Cadmium	<0.04
Chromium	0.46
Copper	<0.02
Lead	<0.8
Nickel	<0.08
Zinc	<0.02
Selenium	<1.2
Silver	<0.04
Mercury	<0.2

* Reduced to 12 mg/L by conventional oil & grease treatment. See Comment 4 in the Conclusions.

011176

Solvent Evaporation/Oil Stripping

Product Oil recovery is accomplished in three steps. First, the bulk of the TEA is removed by simple distillation. Second, the residual TEA is stripped from the oil by steam distillation. Third, the oil is polished to further reduce the residual levels of TEA and water. The TEA azeotrope recovered during the stripping process had low organic contaminant levels, based on color and odor.

No foaming was observed during the above operation and no TEA odor was apparent in the oil at the completion of the steam stripping step.

Product Oil Analysis

Analyte	Result
Viscosity @ 77°F	>1.x10^6 cps.*
PCB's	270. mg/Kg
Arsenic	4.4 mg/Kg
Barium	19. mg/Kg
Cadmium	<1. mg/Kg
Chromium	38. mg/Kg
Lead	30. mg/Kg
Selenium	<6. mg/Kg
Silver	3.5 mg/Kg
Nickel	42. mg/Kg
Zinc	12. mg/Kg
Mercury	<5. mg/Kg

* exceeded viscometer measuring range.

Test Conclusions

The B.E.S.T. process has the capability to extract the organic constituents present in the sludge and concentrate them in the oil fraction.

Key observations include the following:

1) The sludge is chemically compatible with triethylamine.

2) The oil constituents in the sludge were readily extracted into the oil fraction.

3) Extraction of organics from the particulate solids in the sample was achieved. Residual oil content in the product solids was only 1.2%.

4) The product water initially exhibited high Oil & Grease levels (13,000 mg/L), which is not uncommon at elevated pHs (>11). However, a conventional Oil & Grease removal technique was evaluated, and as a result lowered the level to 12 mg/L (99.9% reduction). The type of water treatment that would be used during actual full scale processing would be dependent on the applicable water discharge requirements.

5) Residual TEA concentrations in the separated product fractions were low, as expected.

6) The presence of a 'rag' layer in the decantation step indicates that further work will be necessary to determine what steps would be required to ensure that this layer does not build up in the decanter and also to investigate possible methods of reducing the volume of this component.

7) PCB's were efficiently extracted from the solids to 0.75 ppm (extraction efficiency 99.8%) and the EP Toxicity metals levels are below the Maximum Contamination levels allowed by EPA.

ATTACHMENT 3

Laboratory Results

(Transmittal Letter)

011178

SHERIDAN SITE COMMITTEE

P.O. BOX 266
BELLAIRE, TX 77401

May 4, 1987

Ms. Ruth L. Izraeli
U.S. Environmental Protection Agency,
Region VI
1445 Ross Avenue
Dallas, Texas 75202

Subject: Laboratory Results
Stabilization and Solvent Extraction Testing

Dear Ms. Izraeli:

Per our discussion on April 28, 1988, we are enclosing one complete set of the laboratory results from our stabilization and solvent extraction testing. These results form the current backup for discussions in our Source Control Feasibility Study.

As you pointed out, additional studies and testing in some areas would be appropriate. After your review of the enclosed data, please contact us about extending the Source Control Feasibility Study delivery date so we can include the results of these additional studies.

If you have any questions concerning this matter, please contact me.

Sincerely,

John M. Cotterell, P.E.
Project Manager

JMC:sms:D152
Enclosure
cc: Designated Recipients

011179

Laboratory Analytical Reports
Stabilization and Solvent Extraction Testing

FIELD NO.		MATRIX	CLASS	SOURCE	PURPOSE	DATE	COLLECTOR	LAB NO
The following samples were generated and tested to review stabilization treatment technologies								
SDS-INCIN-	0	SLUDGE	COMPOS	Pond Sludge Subsample	Characterize	22-Jun-87	Birdwell	63942 - 2
SDS-TREAT-	0	WASTE	GRAB	SDS-GEN-0 Subsample	Control	13-Aug-87	Tanner	64298 - 1
SDS-TREAT-	32	WASTE	GRAB	Flyash Stabilization	Test	13-Aug-87	Tanner	64298 - 2
SDS-TREAT-	21	WASTE	GRAB	Rice Hull Ash	Test	26-Aug-87	ENRECO	64417 - 1
SDS-TREAT-	22	WASTE	GRAB	Ash + Port. Cement	Test	26-Aug-87	ENRECO	64417 - 2
SDS-TREAT-	23	WASTE	GRAB	Ash + PC + NaCO3	Test	26-Aug-87	ENRECO	64417 - 3
SDS-TREAT-	61	WASTE	GRAB	SOLIDITECH	Test	28-Aug-87	SOLIDITECH	64435 - 1
SDS-TREAT-	63	WASTE	GRAB	SOLIDITECH	Test	28-Aug-87	SOLIDITECH	64435 - 2
The following samples were generated and tested to review solvent extraction treatment technologies								
SDS-TREAT-	41	OIL	GRAB	B.E.S.T.	Test	01-Sep-87	RCC	64458 - 3
SDS-TREAT-	42	WATER	GRAB	B.E.S.T.	Test	01-Sep-87	RCC	64458 - 2
SDS-TREAT-	43	SOLID	GRAB	B.E.S.T.	Test	01-Sep-87	RCC	64458 - 1

011180

Laboratory Analytical Reports
Stabilization and Solvent Extraction Testing

FIELD NO.	GENERAL ANALYSES	ORGANICS AND METALS
The following samples were generated and tested to review stabilization treatment technologies		
SDS-INCIN- 0	CL, SO4,NH3, TKN, P, K, TOC, O&G, BOD, TSS/VSS	HSL organics, PCBs
SDS-TREAT- 0		TCLP: HSL vol, metals
SDS-TREAT- 32		TCLP: HSL vol, metals
SDS-TREAT- 21		TCLP: HSL metals
SDS-TREAT- 22		TCLP: HSL vol, metals
SDS-TREAT- 23		TCLP: HSL metals
SDS-TREAT- 61		TCLP: HSL volatiles
SDS-TREAT- 63		
The following samples were generated and tested to review solvent extraction treatment technologies		
SDS-TREAT- 41		PCB 8080
SDS-TREAT- 42	O&G	PCBs
SDS-TREAT- 43	O&G	TCLP: HSL vol, semivol, metals; PCBs

011181

APPENDIX E

Review of Incineration Technologies and Preliminary Basis of Design

REVIEW OF INCINERATION TECHNOLOGIES

AND PRELIMINARY BASIS OF DESIGN

011183

February 19, 1988

W.O. #91-12

A868

TABLE OF CONTENTS

SUMMARY

Incineration of approximately 30,000 yd^3 of pond sludge and affected soil at the Sheridan Disposal Services site can be best achieved with a 7 ft (I.D.) x 30 ft rotary kiln system.

This is a very preliminary selection, and presupposes that incineration of sludges and soils with relatively low concentrations of PCBs can in fact be achieved within technical, regulatory and political limitations. Significant technical problems complicate the implementation of incineration, including the need to restrict the variability of feed characteristics, the need to design the facility without a complete knowledge of the feed character, the need to protect worker safety and the difficulty of eliminating toxic products of incomplete combustion. Regulatory problems include the requirement that PCB destruction efficiency must at least equal 99.9999%, and potential NO_x controls. Political problems include the public's concern about: 1) the highly toxic products of incomplete combustion that result from the incineration of PCBs and other waste materials, and 2) the possibility that the facility may be converted to a commercial incinerator upon completion of the site remediation. The cost of incineration is very sensitive to technical and political problems.

Rotary kiln incineration was selected over fluid bed, circulating fluid bed, infra-red, fixed hearth, multiple hearth and rotary hearth incineration because of its flexibility to handle waste that varies physically, thermodynamically and chemically.

Feed preparation begins with the isolation and blending of waste in an impoundment within the main pond. This waste consists of pond sludge, evaporation system sludge, oil surface soil, floating oil and emulsion, and affected soil under the pond. A vacuum dredge transfers a sludge-soil mixture to batch tanks for blending with selected drum wastes. Crushed drums and debris are fed to the incinerator as a supplement to this mixture.

The incinerator is followed by a low pressure drop venturi-type scrubber to remove the large particulate matter and an ionizing wet scrubber to remove finer particles. Aqueous sodium hydroxide (10% solution) is used in the venturi and ionizing scrubbers to neutralize acid gases. The ash is removed dry and cooled in a screw conveyor at the opposite end, below the refractory lined transition section.

REVIEW OF INCINERATION TECHNOLOGIES
AND PRELIMINARY BASIS OF DESIGN

1 - INTRODUCTION

1.1 Purpose and Scope

The primary purpose of this document is to establish a reasonable conceptual design for incineration for the Sheridan Disposal Services (SDS) site for use in developing and comparing remedial alternatives.

The potential applicability of the various incineration technologies to the SDS site has been evaluated on a preliminary basis. A technology is selected and a design developed assuming remediation of all of the pond sludge, evaporation system sludge, oily surface soil, floating oil and emulsion and affected soil under the pond.

1.2 Site Background

Remediation of the SDS site, as preliminarily characterized for this evaluation, involves the treatment of approximately 20,000 yd^3 of sludge and floating oil and emulsion which has a significant caloric value (estimated 6,500 Btu/lb); plus 10,000 yd^3 of oily surface soil, evaporation system sludge, and affected soil under the pond which has minimal heating value; plus an allowance of approximately 1,000 drums of waste material assumed to be similar to the sludge.

The heterogeneity of each of these wastes makes the selection of an incineration system to handle the entire amount difficult. The viscosity of the sludge complicates the materials handling. Also the fact that the pond contains drums or parts of drums to be incinerated limits the possible types of incinerators that might be used.

2 - COMPARATIVE EVALUATION OF INCINERATION SYSTEMS

2.1 General

Hazardous waste incineration in the United States, while practiced since the 1960's, was not regulated until 1982 when the first rules under RCRA were completed. Therefore, from a practical standpoint, incineration is a relatively new technology for hazardous waste disposal. Only a few (20-25) hazardous waste incinerators have received permits to date, and many of these burn liquid waste only. Certain generic or specific incinerator types have been tested for their applicability to hazardous waste destruction and, under the U.S. EPA SITE program, others will be tested and evaluated. For the purpose of selecting a suitable system for the Sheridan site, technologies which have shown some evidence of success on similar wastes have been evaluated. Other emerging technologies are not included here because of limited data on which to base an evaluation.

Candidate incinerator systems which might be considered are the Fluid Bed, Circulating Fluid Bed, Infra-Red, Rotary Kiln, Fixed Hearth Controlled Air, Multiple Hearth, and Rotary Hearth.

In general, the air pollution control systems which would or could be used with any of these incinerators are similar so they will not be discussed with each incinerator type. Each system involves the collection of particulate (ash) in either a dry or wetted form and the neutralization or absorption of acid gas components of the flue gas such as HCl and SO_2. Certain incinerator systems, such as the circulating fluid bed incinerator lend themselves to dry particulate collection, but no incinerator is specifically limited to a single type of air pollution control system.

The leachate characteristics of waste ash are independent of the incinerator type and therefore not relevant to this comparison. Most of the incinerator types discussed have done this in tests or formal trial burns. The decision to use any incinerator must therefore be based on its cost-effectiveness and applicability to the situation.

2.2 Fluid Bed

Fluid bed incinerators are manufactured by several companies. They utilize a bed of sand or alumina suspended or "fluidized" in a pressurized air stream. The waste sludge or finely divided solid waste is injected continuously near the top of the bed. The fluidizing air is initially preheated by burners and later by heat recovery if it is practical. The fluid bed incinerator can operate on a low heating value waste without the addition of auxiliary fuel, because the sand bed holds the heat from the combustion of the waste.

The fluid bed incinerator has been employed for a variety of waste materials from refinery sludges to paper mill "black liquor". It's primary advantage is that it can operate at lower temperatures than most incinerators, thus saving auxiliary fuel. It is, however, sensitive to materials that slag at its operating temperature, which can foul or plug the bed. High ash materials present a different problem because the ash can only be discharged from the system by removing some of the bed material (sand). When burning a high ash waste the sand must be separated from the ash, if possible, and recycled or replaced by fresh bed material.

It is necessary to prepare the waste feed so that it is physically sized to be continuously injected into the bed and that it is thermodynamically consistent in heating value. In practice, this is difficult to achieve in most site remediation situations where there is variability in the waste characteristics.

The fluid bed incinerator is more economical as the capacity increases. It is physically unsuitable as a mobile unit, but it could be considered transportable. It is inherently more expensive than most competitive systems in first cost and lower in operating cost. It could be used on the sludge at the Sheridan site (if drums and debris are removed), but not for the soils or drum waste. No fluid bed incinerator has been permitted, to date, for hazardous waste incineration except for pilot units.

2.3 Circulating Fluid Bed

This system works like a fluid bed and, in addition, employs a water wall combustion chamber/boiler. It is expensive, and there is little or no use for the steam at this site. The waste is injected into the circulating fluid bed, burns and releases its heat. The ash is carried with the fluidized air and combustion products into the cyclone separator. The water wall combustion chamber maintains the reactor temperature, but without a use for the steam it is impractical and expensive. The manufacturer claims that acid gas neutralization can be economically achieved by adding lime to the feed. There is no reason to discount this claim, but the claim is also valid for the fluid bed. The same positive and negative aspects inherent in the fluid bed combustor apply here except that the circulating fluid bed requires the extra cost of the water wall chamber.

The circulating fluid bed is sold by Ogden Environmental Services, who purchased GA Technologies. They offer a transportable version for site remediation. Test burns on their pilot unit on PCB waste have been successful.

2.4 Infra-Red

Infra-red incineration systems are sold by two companies at the present, Shirco and NASS. Both have installations operating on hazardous waste. Shirco has a mobile pilot test unit and has sold a larger transportable unit. Infra-red incineration employs a woven wire belt to transport the waste through the furnace. This unit requires that the waste have no "free" liquids because liquids would run through the belt. The waste on the belt passes beneath electric infra-red heating elements where it is heated to temperatures that volatilize and pyrolize the hydrocarbons present. Air may be added to ignite the waste at any point along the furnace. The flue gases pass into a secondary chamber, fired by gas or fuel oil, where they are further heated and the hydrocarbons destroyed.

At the Sheridan site, the wet sludge would have to be mixed with soil or lime to make it solid enough to be carried on the belt. The soil could be handled by the system as it has been in other locations. The feed is restricted to a maximum size of 1.5 inches in diameter. This would mean a significant amount of costly feed preparation. The real forte of the infra-red incinerator is handling soils. It can save fuel compared to other types because the fuel can be mixed with the soil and the unit runs at low air rates. It is, however, a relatively unproven technology. The only full-scale system has been operating at the Peak Oil site in Florida. It has had significant operational problems with waste feeding and ash removal, and has yet to be fully permitted.

2.5 Rotary Kiln

The rotary kiln incinerator consists of a refractory lined cylinder which rotates slowly on fixed trunnions. The kiln is essentially a moving hearth which promotes mixing between the waste and the combustion air. The kiln is sloped slightly from the feed end to the ash discharge end so that the waste may move along the length of the kiln. It requires between 50% and 100% excess air for normal operation. The kiln is followed by an afterburner, where the organic compounds remaining in the flue gases are destroyed.

A rotary kiln may be fed by a variety of methods. Liquid wastes may be atomized through burners or nozzles. Sludges may be similarly atomized or fed onto the hearth through an open pipe. Solids may be fed through screw feeders, gravity chutes or ram feeders. Ram feeders may charge packaged wastes in combustible containers.

The major disadvantage of the rotary kiln incinerator is that it is less fuel-efficient than many other types. Another disadvantage is the need for close control of temperature. If the temperature is too low, combustion will be incomplete. If the temperature is very high, the refractory will be damaged. Considerable experimentation will be necessary during incinerator startup in order to match the heating value of the waste to the desired kiln temperature. Automatic temperature controls are standard on rotary kiln incinerators, and will require routine attention by a highly skilled instrument technician. As no control is perfect, occasional temperature excursions are inevitable. In addition, the final means of controlling excessive temperature rise is the shutdown of the incinerator.

Excessive temperatures below those which directly damage the refractory can cause problems due to slagging. Slagging occurs when metals in the wastes melt and fuse. At the SDS site, the metals would come from the drum bodies and affected soil. The metal slag can clog the incinerator discharge, requiring a shutdown to clear the clogged areas, and can also damage the refractory. Incinerators can be designed with intentional slagging, but this requires facilities to handle the slag discharge and also requires more costly refractory.

2.6 Fixed Hearth - Controlled Air

This generic incinerator type was developed to handle municipal and industrial combustible waste materials which are non-hazardous. Later it was applied to hazardous waste by several companies, specifically Trade Wastes (now part of Chemical Waste Management) and Thermalkem (formerly Stablex, S.C.). The generic unit consists of a primary chamber with air injection and a secondary chamber fired on auxiliary fuel. The primary chamber can be operated under pyrolitic conditions or with excess air. The secondary chamber is always oxidizing. For wet wastes, such as sludges, the waste is pumped or atomized onto the hearth. A series of stepped hearths, each with a mechanical ram, have been employed to move the material from the feed end to the ash removal section.

This type of incinerator provides satisfactory operation on combustible liquids which can be used as fuel in the secondary chamber and on dry combustible solids. It is a poor choice for wet wastes and sludges or soils, and is therefore not suitable for the Sheridan site. Its primary virtue is its low capital cost. It has been used for hazardous waste and it has been permitted for hazardous waste. It is not easily mobile or transportable. It does not require any special feed preparation.

2.7 Multiple Hearth

The multiple hearth incinerator was widely used for burning sewage sludge in the 1950's and 1960's, but is considered obsolete today. The few companies who built and sold the design are now out of business. It consists of a series of circular refractory hearths one above another. The waste is fed to the top hearth where mechanical arms with rakes move or spread the waste over the hearth. These arms rotate on a column or shaft located at the center of the circle. Each hearth has a segment which opens to the hearth below and the rabble arms gradually bring the waste to the opening where it drops to the lower hearth. The waste moves from hearth to hearth in this manner. Most multiple hearth incinerators consist of four hearths. The first is a drying hearth, the second and third are burning hearths and the last is a cooling hearth. The hearths are fired radially with conventional fuel burners.

The multiple hearth incinerator is suitable for soil and sludges without free liquid. It is not suitable for waste of non-uniform sizes nor is it suitable for wastes with high heating values because it is not a good combustor. A multiple hearth incinerator is field-erected and not mobile or transportable. It is highly mechanical and therefore has a high maintenance cost. None have received RCRA permits to date.

2.8 Rotary Hearth

The rotary hearth incinerator unit is similar to a single hearth of the multiple hearth incinerator, except that the hearth moves around a central shaft and the rabble arms are stationary. It receives its combustion air through the arms and also through the radially mounted burners It requires an afterburner to complete the combustion of the flue gases.

The advantages and disadvantages are similar to the multiple hearth incinerator. It is mechanically simpler, does not lend itself to transportability and is not a particularly good combustor. It will work well on low heating value sludges and soils. One unit is currently preparing for a RCRA trial burn and one has been permitted.

Multiple and rotary hearth incinerators are designed to handle a wide variety of sludges of varying consistency. They can also handle solids prepared to a specific physical size limitation. These incinerators are large, mechanically complex, and have seen limited use with hazardous waste burning. They have no inherent advantage over other more widely used system types for this application and would probably be more costly to build and operate.

2.9 Selection

Of the various incinerator types, the fluid bed, circulating fluid bed, infra-red and rotary kiln types are potentially applicable to the Sheridan site. The fixed hearth-controlled air incinerator is not applicable because it will not burn soils and sludges well and the multiple and rotary hearths will be hard to control with the high heating value of the waste.

The fluid bed incinerator has not been used in site remediation and has had limited use on hazardous waste. It requires a consistent feed that would be difficult to achieve at the Sheridan site. The circulating fluid bed has the same shortcomings, plus it must produce steam. Since steam is not needed at the site, there is no economic advantage for the circulating fluid bed.

The infra-red incinerator has been used for similar wastes but extensive feed preparation would probably be required (for example, sludge solidification and waste pulverizing). The expense of this waste preparation could easily offset any capital cost advantage this system may have over the rotary kiln incinerator. Previous field problems with similar sludge wastes indicate that this system may, in fact, not be practical for Sheridan site wastes.

The rotary kiln incinerator appears to be the best selection to develop the design basis for incineration at the Sheridan site. This design basis is used in the Source Control Feasibility Study to develop incineration cost estimates. The costs developed for rotary kiln incineration will be representative of the incineration option in general, in that the rotary kiln incinerator is generally less expensive than either of the fluid bed systems and about equivalent to the infra-red incinerator in first cost for the same application.

3.1 Design Basis

The estimated waste quantities and properties and other assumptions used in the incineration design are given in Table 3-1. The heat and material balance for this incinerator is shown on the flow diagram, Figure 3-1. The design basis is given in Table 3-2.

Proper preparation of the waste is essential if incineration is to be successful. This preparation must consist of a combination of waste segregation and mixing designed to minimize operational upsets due to variable or uncertain feed quality. Thorough mixing is required because rapidly varying waste characteristics result in incinerator upsets, lowered waste constituent destruction efficiencies, and release of potentially toxic compounds to the atmosphere via the incinerator stack. Widely varying feed characteristics may also cause wide variations in operating temperatures, resulting in damage to the incinerator refractory or other components. This has the effect of increasing downtime and maintenance costs.

3.2 Incineration System Description

A rotary kiln with an afterburner has been selected for this conceptual design and cost estimate. Natural gas is used as the auxiliary fuel. The incinerator is followed by an adiabatic quench, a low pressure drop venturi-type scrubber to remove the large particulate matter, and an ionizing wet scrubber. Aqueous sodium hydroxide (10% solution) is used in the venturi and ionizing scrubbers to neutralize acid gases. Figure 3-1 shows a flow diagram of the conceptual incinerator design.

The rotary kiln incinerator system selected for this study consists of a refractory-lined rotary kiln which is fed sludge through a pipe or lance via a positive displacement pump. Soil, and any drums found in the sludge or soil, is conditioned to size through a shredder or similar device followed by a bar screen. These are fed into the kiln through an auger. Natural gas is fired through a burner located at the feed end of the kiln. This auxiliary fuel is used for heat during startup and as needed to supplement the heating value of the waste.

The ash is removed dry and cooled in a screw conveyor at the opposite end, below the refractory lined transition section. Flue

TABLE 3-1

INCINERATION DESIGN ASSUMPTIONS
SHERIDAN DISPOSAL SERVICES SITE

Impoundment Sludge

Averages of laboratory test results for fifteen sludge samples were used for the sludge composition. This data was used to derive the following estimated sludge composition which was used in the calculations:

Carbon	-	35.23 %
Hydrogen	-	2.44 %
Oxygen	-	6.54 %
Chlorine	-	0.03 %
Sulfur	-	1.50 %
Water	-	44.00 %
Ash	-	10.00 %

Higher Heating Value	=	6,500 Btu/lb
Average Specific Gravity	=	1.06 (66.1 lb/cu.ft.)
Sludge Volume	=	20,000 cu. yds.
Total Sludge Weight	=	35,700,000 lb (17,850 tons)

Note: The sample determinations for heating value averaged 4,750 Btu/lb using the detection limit of 150 Btu/lb for those samples showing no heating value. The heating values were not consistent with oil content, however, so an average oil content for the 15 samples was calculated at 37.96% and multiplied by 18,000 as a heating value for waste oil, giving 6,830 Btu/lb. From these two numbers, the 6,500 Btu/lb figure was chosen as the probable average.

Drum Waste

The drum contents have been assumed to have the same average composition and heating value as the sludge.

Drum Volume	=	1,000 full drums
Total Drum Weight	=	486,600 lb (243 tons)

011194

TABLE 3-1 (Cont'd)

INCINERATION DESIGN ASSUMPTIONS

SHERIDAN DISPOSAL SERVICES SITE

Oily Surface Soil, Evaporation System Sludge, And Affected Soil Under the Pond

The subject soils have been assumed to have the following composition:

Carbon	-	1.13 %
Hydrogen	-	0.12 %
Oxygen	-	2.46 %
Nitrogen	-	1.00 %
Chlorine	-	0.10 %
Sulfur	-	0.20 %
Water	-	20.00 %
Ash	-	75.00 %

Higher Heating Value	=	100 BTU/lb
Density	=	100 lb/cu. ft.
Impoundment Soil Volume	=	10,000 cu. yd.
Total Impoundment Soil Weight	=	27,600,000 lb (13,500 tons)

Other Assumptions

1. An operating year of 6570 hours, which is 75% on-line
2. Soils, sludges and drums will be incinerated simultaneously over a two year period using a single incinerator.
3. Natural gas will be the auxiliary fuel.

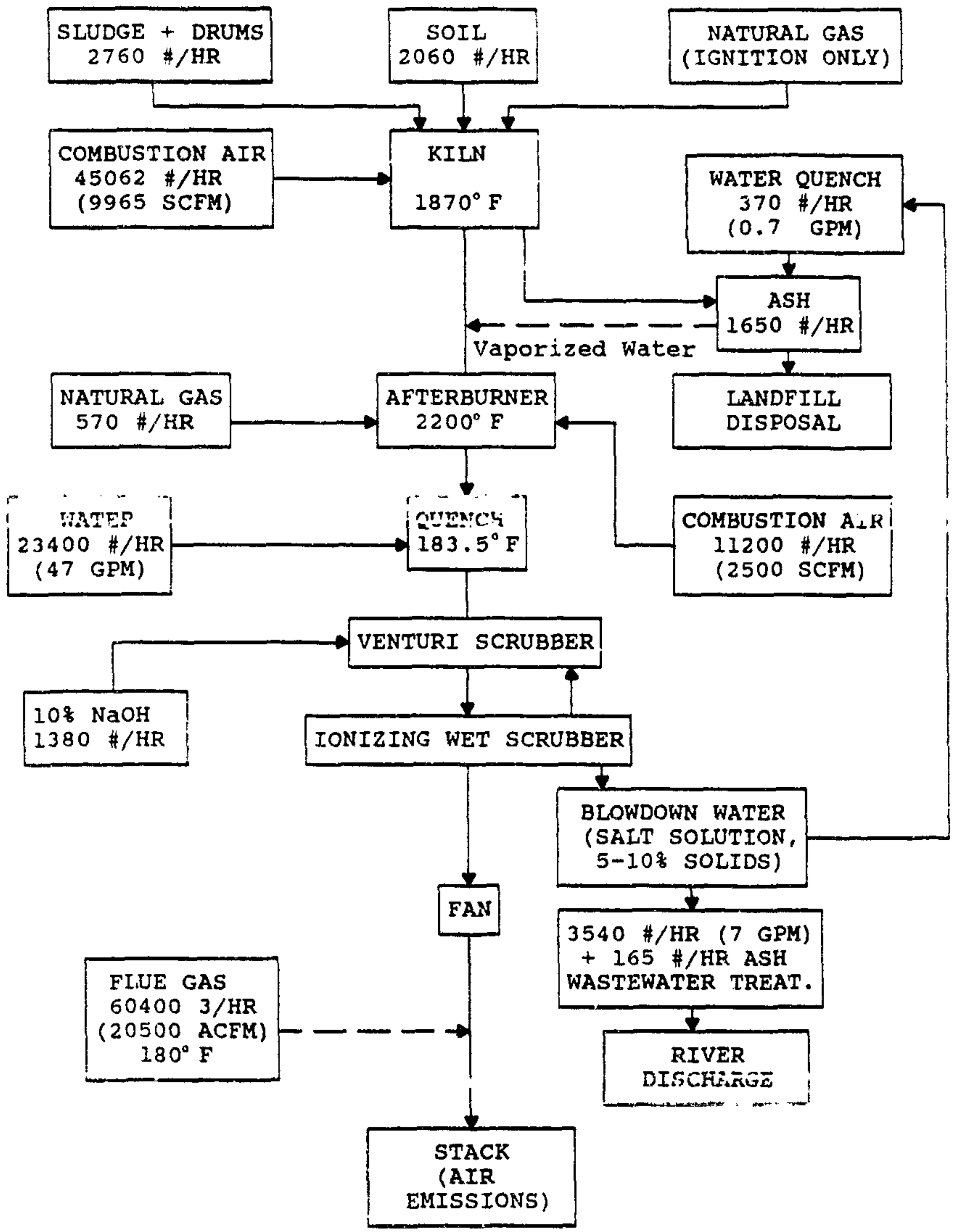
Design Flow Basis

A. 2,760 lb/hr of sludge & drums

B. 2,000 lb/hr of soil

FIGURE 3-1

FLOW DIAGRAM SHOWING HEAT AND MATERIAL BALANCE



Note: Numbers Rounded

011196

TABLE 3-2

CONCEPTUAL DESIGN BASIS
INCINERATION
SHERIDAN SUPERFUND SITE

(A)	Kiln Feed	
	Sludge Lance	- 3" Inconel water cooled pipe
	Soil Feeder	- 3" dual screw feeder with screen
(B)	Kiln Burner	- Natural gas forced draft type, 5,000,000 Btu/hr
(C)	Rotary Kiln	
	Material	- Welded Carbon Steel
	Outside Diameter	- 8'- 8"
	Inside Diameter	- 7'- 0"
	Length	- 30'
	Supports	- Steel trunnions
	Drive	- Girth gear w/variable speed drive from electric motor
	Speed	- Variable 0.5 to 2 RPM
	Slope	- 1.5 degrees
	Refractory	- 6" Firebrick 3" Hi temp insulated brick
	Operating Temperature	- 1500°F to 1900°F
	Shell Temperature	- 300°F to 400°F
	Total Heat Release	- 20,000,000 Btu/hr
	Heat Release/Volume	- 15,000 Btu/cu.ft./hr
	Operating Pressure	- 0.1 to 0.5 " w.c. negative
	Excess Air	- 70%
	Flue Gas Outlet Velocity	- 12 ft/sec
(D)	Transition Section	- Refractory-lined carbon steel
(E)	Ash Handling System	
	Type	- Dry ash removal
	Ash Cooling	- Water Sprays
	Ash Doors	- Slide Gate Type
	Ash Conveyor	- Water cooled screw conveyor

011197

TABLE 3-2 (Cont'd)

CONCEPTUAL DESIGN BASIS
INCINERATION
SHERIDAN SUPERFUND SITE

(F) Afterburner

Material	-	3/8" Carbon Steel
Inside diameter	-	8'-0"
Outside Diameter	-	9'6 3/4"
Height	-	40'
Refractory	-	4 1/2" firebrick over 4 1/2" insul. brick.
Shell Temperature	-	350°F
Internal Volume	-	2050 cu.ft.
Operating Temperature	-	2200°F
Flue Gas Residence Time	-	2 seconds (minimum)
Heat Release	-	13,600,000 Btu/hr
Burners	-	One high intensity forced draft burner rated at 18,000,000 Btu/hr each

0111198

(G) Adiabatic Quench

Type	-	Spray tower
Material	-	Carbon steel shell
Lining	-	4" acid brick over Pyroflex membrane liner
Inside Diameter	-	6'6"
Outside Diameter	-	7'6"
Height	-	23'

(H) Venturi Scrubber

Material	-	FRP inlet & outlet with Hastalloy variable throat
Arrangement	-	Vertical down flow
Design Pressure Drop	-	10" w.c.

TABLE 3-2 (Cont'd)

CONCEPTUAL DESIGN BASIS
INCINERATION
SHERIDAN SUPERFUND SITE

(I) Ionizing Wet Scrubber

Model	-	Ceilcote Model IWS 900
No. of Parallel Trains	-	1
No. of Stages/Train	-	3
Construction	-	FRP with Hastalloy plates
Approx. Overall Dimen.	-	55' long x 28' wide x 23' high

(J) Induced Draft Fan

Material	-	Carbon steel
Temperature	-	180°F
Flow	-	21,000 acfm
Pressure	-	25" w.c. negative.
Drive	-	V-belt
Motor	-	125 h.p.

(K) Stack

Material	-	Coated carbon steel
Inside Diameter	-	3'0"
Height	-	75'
Velocity	-	50 fps

(L) Feed Preparation System

Tanks for Segregation & Blending of Liquid Drum Contents	-	6 carbon steel, 5,000 gallons each, propeller side mixers
Blending Tanks for Sludge and Liquids	-	3 carbon steel, open-top, 12,000 gallons each, high torque low rpm mixer
Solids Staging Area	-	Concrete pavement 8" curbing
Solids Mixing and Handling	-	Front-end loader, tractor type approximately one cu.yd. capacity
Solids Feed to Incinerator	-	Belt conveyor w/discharge hopper
Pond Dredge	-	Cutter head type

gases from the transition section pass into a vertical afterburner where they are further heated to 2200°F by two natural gas burners each with a capacity of 20,000,000 Btu/hr. Airborne ash which drops to the floor of the afterburner must be removed periodically.

The 2200°F flue gases then pass into a refractory-lined quench tower where they are adiabatically cooled by water sprays to 184°F. The wetted and cooled flue gases then pass through an adjustable throat Venturi scrubber where 90% of the remaining particulate material is removed, then through a packed bed crossflow prescrubber, and finally into a three stage Ceilcote ionizing wet scrubber for the removal of fine particulates.

A 10% sodium hydroxide solution contacts the flue gases in both the Venturi scrubber and the crossflow scrubber to neutralize any acid gases present in the flue gas. The clean gases then pass through the induced draft fan and a mist eliminator into the discharge stack.

3.3 Ash Disposal

For the Sheridan site, ash from the incinerator would be disposed of off-site.

4.1 Conclusions

1. Among alternative incineration options, rotary kiln incineration with a wet ionizing scrubber appears to be the most suitable design basis for incineration.

2. Any incineration system will have to incorporate a materials handling facility to adequately blend and characterize the waste.

3. An incineration system will have to destroy PCBs with a 99.9999% efficiency.

4. Public opinion is generally against incineration at this site because of concerns about air quality and commercialization of the facility.

5. Significant material handling operations will be needed at the SDS site to assure a homogeneous, fully characterized feed to the incinerator.

6. Other design and operating concerns include possible NO_x limitation and worker safety.

7. Incineration of soils and sludges at Superfund sites is not sufficiently proven for the cost to be reasonably predicted.

4.2 Recommendations

1. Base analysis of incineration as a remediation alternative on rotary kiln incineration with a wet ionizing scrubber.

2. Base analysis of incineration as a remediation alternative on a feed preparation system that incorporates sludge isolation, blending tanks, drum characterization and mixing facilities, and solids handling and feed facilities.

APPENDIX F

Concept Design Tables

Waste and Soil Volumes

Materials	Initial Volume	Mixing Ratio	Volume increase [a]	Final
	1000 yd3	soil waste		1000 yd3
Pond Sludge, Emulsion	30	6:1	600%	180
Evaporation System Sludge	1	2:1	250%	3
Oily Surface Soil	3	2:1	250%	8
Affected Soil Under Pond	10	2:1	250%	25
	44			215

Wastewater Volumes

Wastewater	First Year Area & Volume		Later Years [b] Area & Volume		Total	
	acres	mg	acres	mg/yr	mg	
Source						
Decontamination		0.5		0.5	1	Allowance
Process		4		0	4	Pond water
Affected Runoff						
Grass Cover	1	0.4	1	0.4	1	Allowance
Bare Ground	22	15.8	11	7.9	24	Main Pond
Pavement	1	1.1	1	1.1	2	Allowance
		22		10	32	160,000 yd3
Disposition						
Evaporate		10		0	10	
Treat & Discharge		12		10	22	

[a] Assumes 100% volume absorption of sludges and oils by soil additive
[b] Time to complete remediation, years = 2

011203

Waste and Soil Volumes

Materials	Initial Volume	Vol Increase Due to Stabilization	Final Volume
	1000 yd3		1000 yd3
Pond Sludge, Emulsion	30	20% [a]	36
Evaporation System Sludge	1	20%	1
Oily Surface Soil	3	20%	4
Affected Soil Under Pond	10	20%	12
	44		53

Wastewater Volumes

Wastewater	First Year Area & Volume		Later Years [b] Area & Volume		Total	
	acres	mg	acres	mg/yr	mg	
Source						
Decontamination		0.5		0.5	1	Allowan
Process		4		0	4	Pond Wa
Process		1		0	1	Free Wa
Affected Runoff						
Grass Cover	1	0.4	1	0.4	1	Allowan
Bare Ground	22	15.8	11	7.9	24	Main Po
Pavement	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]
		22		10	32	160,000
Disposition						
Evaporate		10		0	10	
Treat & Discharge		12		10	22	

[a] Based Table 2-6, Appendix D, Samples No's 1 through 8
[b] Time to complete remediation, years = 2

011204

Waste and Soil Volumes

Materials	Initial Volume	Volume After Treat.	Vol Increase Due to Stabilization	Final Volume
	1000 yd3	1000 yd3		1000 yd3
Pond Sludge, Emulsion	30	19 5 [a]	20%	23 4
Evaporation System Sludge	1	0 8 [b]	20%	0 9
Oily Surface Soil	3	2 3 [b]	20%	2 7
Affected Soil Under Pond	10	10 0	20%	12 0
	44	32 5		39 0

Wastewater Volumes

Wastewater	First Year Area & Volume		Later Years [c] Area & Volume		Total	
	acres	mg	acres	mg/yr	mg	
Source						
Decontamination		0 5		0 5	2	Allowan
Process		0 3		0 3	1	
Affected Runoff						
Grass Cover	1	0 4	1	0 4	1	Allowan
Bare Ground	22	15 8	13	9 4	35	Main Po
Pavement	2	2 1	2	2 1	6	Allowan
		19		13	44	220 000
Disposition						
Evaporate		10		0	10	
Biotreatment Evaporative Loss		5		5	15	
Treat & Discharge		4		8	19	

[a] Assumes 35% pond sludge volume reduction in 30 days, based on observations made during Phase 2 biological treatment testing
[b] Assumes 25% sludge and soil volume reduction in 30 days Assumption is based upon observation of oily surface soil and engineering judgement
[c] Time to complete remediation, years = 3

011205

Waste and Soil Volumes

Materials	Initial Volume	Resid Solids	Density	Resid Solids
	1000 yd3	Dry Tons	lb/ft3	1000 yd3
Pond Sludge, Emulsion	30	4,020	50	6 0
Evaporation System Sludge	1	780	50	1 2
Oily Surface Soil	3	2,350	50	3 5
Affected Soil Under Pond	10	7,830	50	11 6
	44	14,980		22 2

Materials	Increase Due to Stabilization	Final Solids Volume	Resid Oil	Resid Water
		1000 yd3	1000 gal	1000 gal
Pond Sludge, Emulsion	0% [a]	6	2860	2890
Evaporation System Sludge	0%	1	50	80
Oily Surface Soil	0%	3	140	240
Affected Soil Under Pond	0%	12	480	780
		22	3530	3990

Wastewater Volumes

Wastewater	First Year Area & Volume (acres)	First Year Area & Volume (mg)	Later Years [b] Area & Volume (acres)	Later Years [b] Area & Volume (mg/yr)	Total (mg)	
Source						
Decontamination		0 5		0 5	2	
Process		4		0	4	Pond Wa
Process		4		4	16	Scrubbe
Process		1.0		1.0	4	Resid.
Affected Runoff						
Grass Cover	1	0 4	1	0 4	2	Allowan
Bare Ground	16	11.5	11	7 9	35	Main Po
Pavement	2	2 1	2	2 1	8	Inciner
		24		16	72	350,000
Disposition						
Evaporate		10		0	10	
Treat & Discharge		14		16	62	

[a] Assumes that the stabilization matrix will use the voids volume
[b] Time to complete remediation, years = 4

011206

Waste and Soil Volumes

Materials	Initial Volume (a)	Initial Solids	Solids Des-troyed	Ash	Scrubber Ash
	1000 yd3	Dry Tons		Dry Tons	Dry Tons
Pond Sludge, Emul., Drums	30	4,020 [b]	50%	1,827	183
Evaporation System Sludge	1	780 [c]	50%	355	35
Oily Surface Soil	3	2,350 [c]	50%	1,068	107
Affected Soil Under Pond	10	7,830 [c]	50%	3,559	356
	44	14,980		6,809	681

Materials	Ash Density & Vol		Scrubber Ash Compacted (d) Density & Vol	
	lb/ft3	yd3	lb/ft3	yd3
Pond Sludge, Emulsion	30	4,512	120	113
Evaporation System Sludge	50	525	120	22
Oily Surface Soil	50	1,582	120	66
Affected Soil Under Pond	50	5,273	120	220
		11,892		420

Wastewater Volumes

Wastewater	First Year Area & Volume		Later Years (e) Area & Volume		Total	
	acres	mg	acres	mg/yr	mg	
Source						
Decontamination		0.5		0.5	3	
Process		4		0	4	Pond water
Process		4		4	20	Scrubber
Affected Runoff						
Grass Cover	1	0.4	1	0.4	2	Allowance
Bare Ground	16	11.5	11	7.9	43	Main Pond
Pavement	2	2.1	2	2.1	11	Incinerator
		23		15	82	410,000 yd3
Disposition						
Evaporate		10		0	10	
Treat & Discharge		13		15	72	

[a] Total 350 billion BTU. Appendix E incinerator design based on 20,300 yd3 pond sludge, 10,000 yd3 of affected soils with total 235 billion BTU 20 million BTU/hr

[b] 70 lb/ft3, 15% solids by weight

[c] 50% sludge as [a], 50% soil at 125 lb/ft3 wet weight, 30% voids

[d] Compacted because it is landfilled as wastewater treatment sludge

[e] Time to complete remediation, years = 5

011207

APPENDIX G

Cost Estimate Tables

011208

SITE UTILITIES & FACILITIES
SHERIDAN DISPOSAL SITE
Revised: 30 May 1988
(Costs in thousands)

	ALT. B - SOIL MIXING	ALT. C - STAB- ILIZATION	ALT. D - BIO- TREATMENT	ALT. E - SOLVENT EXTRACTION	ALT. F - INCINERATIO	REF.
CAPITAL						
Wastewater	$400	$400	$350	$400	$400	
Laboratory	30.00	150.00	150.00	150.00	300.00	
Potable water & piping	68.00	68.00	68.00	68.00	68.00	G.2-2
Nonpotable water & piping	72.00	72.00	72.00	72.00	72.00	G.2-2
Lighting	10.00	10.00	10.00	10.00	10.00	
Trailers	15.00	15.00	15.00	15.00	15.00	
Decontam. Area	15.00	15.00	15.00	15.00	15.00	
TOTAL CAPITAL COST	$610	$730	$680	$730	$880	
TOTAL TREATMENT COSTS						
Total Wastewater, Mg	22	22	19	62	72	
Treatment cost, $/1000 gal	$5.00	$5.00	$5.00	$5.00	$5.00	
TOTAL WW TREATMENT COST	$110	$110	$95	$310	$360	
ANNUAL OPERATING COSTS						
Operating Period, yr	2	2	3	4	5	
Water treatment cost	$10	$10	$10	$10	$10	
Laboratory costs	70.00	300.00	300.00	300.00	400.00	
Security	114.00	114.00	114.00	114.00	114.00	G.2-7
TOTAL OPERATING COST	$388	$848	$1,272	$1,696	$2,620	
TOTAL CAPITAL, TREATMENT AND OPERATING COSTS (rounded)	$1,108	$1,688	$2,047	$2,736	$3,860	

NOTES:
1. Costs are in thousands of dollars unless specified otherwise.
2. Totals are capital cost plus the operating cost times the estimated period of operation for the alternative.
3. Operating costs cover construction & treatment period only; post-closure analytical costs covered separately.

011209

8375 OPTIONS

SLUDGE ISOLATION
SHERIDAN DISPOSAL SITE
Revised: 6 May 1988

Item	Quantity	Units	Unit Cost	Ref.	Protective Level	Labor Factor	Cost	Notes
Design waste quantities:								
Sludge & emulsion	30,000							
Oily soil	4,000	cy						
Pond affected soil	10,000	cy						
Isolation dike, 12' height	1,000	lf	$64.00	G.2-1	D	1.00	$64,000	"East-West Dike"
Isolation dike volume	14,000	cy						Need for fill calc'
Pump 15% sludge & emulsion	4,500	cy	$3.00	G.2-5	B/C	5.75	77,625	
Excavate & haul 15% affected soil	2,100	cy	$5.50	[illegible].2-5	B/C	5.75	66,413	
Pump 100% sludge & emulsion	30,000	cy	$3.00	G.2-6	B/C	5.75	517,500	
Excavate & haul 100% affected soil	14,000	cy	$5.50	G.2-6	B/C	5.75	442,750	
TOTAL ESTIMATED SLUDGE ISOLATION COST							$1,168,000	Rounded

NOTES:

1. This table presents estimated costs to the General Contractor as of mid-1987.
2. Costs do not include General Contractor overhead & profit, contingency, engineering & construction surveillance, or quality control/quality assurance testing.

011210

MIX SLUDGE WITH CLAY-RICH SOIL
SHERIDAN DISPOSAL SITE
Revised: 6 May 1988

Item	Quantity	Units	Unit Cost	Ref.	Protective Level	Labor Factor	Cost	Notes
Design waste quantities:								
Sludge & emulsion	30,000							
Oily soil	4,000	cy						
Pond affected soil	10,000	cy						
Mix sludge with soil (6:1)	30,000	cy	$32.00	G.2-3	C	1.70	$1,632,000	
Mix affected soil (2:1)	14,000	cy	$15.80	G.2-3	C	1.70	376,040	
TOTAL ESTIMATED SOIL MIXING COST							$2,008,000	Rounded

NOTES:

1. This table presents estimated costs to the General Contractor as of mid-1987.
2. Costs do not include General Contractor overhead & profit, contingency, engineering & construction surveillance, or quality control/quality assurance testing.

CAP
SHERIDAN DISPOSAL SITE
Revised: 6 May 1988

Item	Quantity	Units	Unit Cost	Ref.	Protective Level	Labor Factor	Cost	Notes
Cap area (rounded)	27.00	ac						
Cap	1,176,000	sf	$1.70	G.2-1	D	1.00	$1,999,200	
Attic fill	370,000	cy	$4.50	G.2-6	D	1.00	1,665,000	
Supplement existing dike	15,000	cy	$5.00	G.2-6	D	1.00	75,000	
Topsoil for dike (12")	7,700	cy	$12.00	G.2-6	D	1.00	92,400	
Seed & fertilize dike	207,000	sf	$0.05	G.2-5	D	1.00	10,350	
TOTAL ESTIMATED CAP COST							$3,842,000	Rounded

NOTES:

1. This table presents estimated costs to the General Contractor as of mid-1987.
2. Costs do not include General Contractor overhead & profit, contingency, engineering & construction surveillance, or quality control/quality assurance testing.

011212

BIOTREATMENT
SHERIDAN DISPOSAL SITE
Revised: 3 June 1988

Item	Quantity	Units	Unit Cost	Ref.	Protective Level	Labor Factor	Cost	Notes
Design waste quantities:								
Sludge & emulsion	30,000	cy						Treated/Stabilized
Volume after treatment	65% [3]							
Oily soil	4,000	cy						Treated/Stabilized
Volume after treatment	75%							
Pond affected soil	10,000	cy						Stabilized
Treatment detention time	30 days							
Tanks 20'H X 82'D	4	●	$349,288		D	1.00	$1,400,000	
5000 gal. holding tank w/ mixer	1	●	$14,000	G.2-3	D	1.00	14,000	
12000 gal. blending tank w/ mixer	1	●	$22,000	G.2-3	D	1.00	22,000	
Pump sludge for treatment	30000	cy	$3.00	G.2-5	C	1.70	153,000	Sludge pumping
Pump oily soil for treatment	4000	cy	$5.50	G.2-5	C	1.70	37,400	Excavate & haul
Down draft aerators (25 hp)	8	●	$20,306		D	1.00	162,450	Vendor estimate
Aerator maintenance:								
Cleaning (1 per 2 batches)	48	●	$400		C	1.70	32,640	Vendor estimate
Propeller replacement	16	●	$1,000		D	1.00	16,000	Vendor estimate
Motor rebuilds (20%)	2	●	[illegible]		D	1.00	[illegible],000	Vendor estimate
Sludge circulation system	4	●	[illegible]		D	1.00	537,618	Vendor estimate
Power	7400000	kwh	$0.10		D	1.00	740,000	
Fume incinerator (capital cost)							500,000	
Fume incinerator (operation)	2	yr	$75,000		D	1.00	150,000	
Stabilize sludge and soil	32,500	cy	$85.00	G.2-5	D	1.00	2,762,500	Residue & affected soil
Supervisor	4	man/yr	$80,000	G.2-6	D	1.00	480,000	Allowance
Operator	4	man/yr	$36,000	G.2-6	C	1.70	489,600	
Laborer	8	man/yr	$25,000	G.2-6	C	1.70	680,000	
Pilot testing							750,000	
Start up							824,300	
TOTAL ESTIMATED BIOTREATMENT COST							$9,815,000	Rounded to thousands

NOTES:
1. This table presents estimated costs to the General Contractor as of mid-1987.
2. Costs do not include General Contractor overhead & profit, contingency, engineering & construction surveillance, or quality control/quality assurance testing.
3. Estimated 35% reduction after 30 days of treatment

011213

8375 (PT'ONS 8.1-8

SOLVENT EXTRACTION
SHERIDAN DISPOSAL SITE
Revised: 20 July 1988

	Quantity	Units	Unit Cost	Ref.	Protective Level	Labor Factor	Cost	
Mobilization/Demobilization							$480,000	Vendor quote
Feed Preparation System							$198,000	
Transfer sludge to treatment	30,000	cy	$3.00	G.2-6	C	1.70	153,000	Sludge pumping
Transfer oily soil to treatment	4,000	cy	$5.50	G.2-.	C	1.70	37,400	Excavate & haul
Transfer affected soil to treat	10,000	cy	$5.50	G.2-6	C	1.70	93,500	
5000 gal hold tank; heated, mixed	1.00	ea	$34,000		D	1.00	34,000	
Solvent extraction	44,000	cy	$115				5,060,000	Vendor quote
Incinerator site preparation							300,000	
Incinerator trial burn							100,000	
Liquid incinerator - capital							1,800,000	Allowance
Incinerator start-up							210,000	
Off-site incinerator ash disposal	132	tons	$172		D	1.00	22,762	
Wastewater pretreatment system	1	ea	$20,000		D	1.00	20,000	
Wastewater pretreatment operation	3,970,000	gal	0.05		D	1.00	198,500	
Power (incidental)	1,140,000	kwh	$0.10		D	1.00	114,000	Residue & affected soil
Stabilize soil/ residue	10,633	cy	$85.00	G.2-5	D	1.00	903,779	
Pilot testing							75.,000	
Start-up							$1,047,294	
SUBTOTAL ESTIMATED SOLVENT EXTRACTION COST							$11,520,235	
ANNUAL INCINERATION OPERATING COST:								
Labor (40 hr/week each):								
Supervisor	1.00	ea	$60,000	G.2-6			$60,000	
Mechanic	1.00	ea	$44,000	G.2			44,000	
Operators	5.00	ea	$38,000	G.2-3			180,000	
Asst. Operators	5.00	ea	$30,000	G.2-6			150,000	
Laborer	5.00	ea	$25,000	G.2-1			125,000	
Chemist	2.00	ea	$35,000	G.2-6			70,000	
Per Diem and Expenses	6	yr	$35,500				$215,000	
Subtotal Labor							$848,000	
Utilities (6570 hr/yr):								
Electricity	560,000	kwh	$0.10				$56,000	
Water							--	Site Utilities
Natural gas (1000 BTU/scf)							--	Startup
Sodium hydroxide	460.00	ton	$300				138,000	
Compressed air							8,000	
Subtotal Utilities							$212,000	
Maintenance							$336,720	
Insurance							280,600	
Taxes							56,120	
TOTAL ANNUAL INCINERATION COST							$1,733,000	
Incinerator operation	1.58	yr	1733000				2,678,328	
TOTAL ESTIMATED SOLVENT EXTRACTION COST							$14,198,000	Rounded to thousands

NOTES:
1. This table presents estimated costs to the General Contractor as of mid-1987.
2. Costs do not include General Contractor overhead & profit, contingency, engineering & construction surveillance, or quality control/quality assurance testing.

011214

INCINERATE SLUDGE
SHERIDAN DISPOSAL SITE
Revised: 20 July 1988

Item Description	Quantity	Units	Unit Cost	Ref.	Protective Level	Labor Factor	Cost	Notes
Design waste volume	44,000	cy						Sludge + pond soil
Design waste BTU	348,800	mil BTU						
Thermal capacity	20	mil BTU/hr						
Utilization	75%							
Time to incinerate	2.7	yr						
Incinerator ash	12,000	cu yd						
CAPITAL COSTS:								
Natural gas pipeline							$165,000	2" line, 1/2 mi.
Feed preparation system							555,000	see derived cost
Incinerator area paving	9,000	sf	$9.50	G.2-6	D	1.00	86,000	excludes feed area
Incinerator foundation							110,000	Allowance
Perimeter dike	1,000	lf	$64.00	G.2-1	D	1.00	64,000	Rounded
Drum shredder							110,000	vendor quote
Sludge feed pump & lance							18,000	
Solids feeder							80,000	
Rotary kiln & drive							450,000	
Kiln burner system							22,000	
Transition system							70,000	
Ash removal equipment							70,000	
Afterburner							220,000	
Afterburner burner system							100,000	
Emergency vent							60,000	
Adiabatic quench							100,000	
Venturi scrubber							70,000	
Ionizing wet scrubber							820,000	
Caustic system							20,000	
Main fan							20,000	
Stack & platforms							60,000	
Ductwork							100,000	
Structural & mechanical							170,000	
Electrical							150,000	
Instrumentation (control and monitoring)							1,000,000	
Control room							100,000	
Trial burn (incl. plan prep., sampling & analyses)							140,000	
Refractory replacement (kiln & afterburner)							200,000	
Start-up							510,000	
TOTAL INCINERATION CAPITAL COST							$5,612,000	
ANNUAL INCINERATION OPERATING COST:								
Labor (40 hr/week each):								EPM-SW estimates
Supervisor	1	e	$60,000	G.2-6			$60,000	
Mechanic	1	e	$44,000	G.2-6			$44,000	
Instrument technician	1	e	$55,000	G.2-6			$55,000	
Operators	5	e	$38,000	G.2-6			$190,000	
Asst. operators (2/shift)	10	e	$30,000	G.2-6			$300,000	
Laborer	10	e	$25,000	G.2-6			$250,000	
Chemist	2	e	$35,000	G.2-6			$70,000	
Per Diem and Expenses	8	yr	$36,500				$292,000	
Subtotal Labor							$1,251,000	
Utilities (6570 hr/yr):								
Electricity	1,580,000	kwh	$0.10				$158,000	
Water							—	Covered elsewhere
Natural gas (1000 BTU/scf)	115,000	M scf	$3.80	G.2-6			437,000	17,500 scf/hr
Sodium hydroxide	460.00	ton	$300				138,000	140 lb/hr
Compressed air							8,300	
Subtotal Utilities							$741,000	
Maintenance							$336,720	6% of capital
Insurance							280,600	5% of capital
Taxes							56,120	1% of capital
TOTAL ANNUAL INCINERATION COST							$2,365,000	Rounded
TOTAL ESTIMATED INCINERATION COST							$12,010,000	Rounded
ESTIMATED INCINERATION UNIT COST							$290	

NOTES:
1. This table presents estimated costs to the General Contractor as of mid-1987.
2. Costs do not include General Contractor overhead & profit, contingency, engineering & construction surveillance, or quality control/quality assurance testing.

011215

LINER
SHERIDAN DISPOSAL SITE
Revised: 15 July 1988

Item	Quantity	Units	Unit Cost	Ref.	Protective Level	Labor Factor	Cost	Notes
SOIL MIXING LINER								
Bottom liner	523,000	sf	$6.36	G.2-4	D	1.00	3,325,995	
Side liner	261,000	sf	$5.50	G.2-4	D	1.00	1,435,210	
Leachate handling facilities			$30,000		D	1.00	30,000	Allowance
Total Estimated Liner Cost - Soil Mixing							$4,791,000	Rounded
STABILIZATION LINER								
Design volume—stabilization	53,000	cy						
Height of liner	7.5	ft						
Bottom lenth	286	ft						
Bottom liner	81,900	sf	$6.36	G.2-4	D	1.00	520,839	
Side liner	27,800	sf	$5.50	G.2-4	D	1.00	152,869	
Leachate handling facilities			$30,000		D	1.00	30,000	Allowance
Total Estimated Liner Cost - Stabilization							$704,000	Rounded
BIOTREATMENT LINER								
Design volume—biotreatment	39,000	cy						
Height of liner	7.5	ft						
Bottom lenth	242	ft						
Bottom liner	58,600	sf	$6.36	G.2-4	D	1.00	372,664	
Side liner	23,800	sf	$5.50	G.2-4	D	1.00	130,874	
Leachate handling facilities			$30,000		D	1.00	30,000	Allowance
Total Estimated Liner Cost - Biotreatment							$534,000	Rounded

NOTES:
1. This table presents estimated costs to the General Contractor as of mid-1987.
2. Costs do not include General Contractor overhead & profit, contingency, engineering & construction surveillance, or quality control/quality assurance testing.

011216

DERIVED UNIT COSTS
SHERIDAN DISPOSAL SITE
Revised: 20 July 1988

Item	Quantity	Units	Unit Cost	Cost	Notes
Caps:					
Vegetation	1.0	sf/sf	$0.05	$0.05	
Topsoil	1.0	ft/sf	$0.44	0.44	
Compacted clayey soil	3.0	ft/sf	$0.30	0.89	
Gas collection system	1.0	sf/sf	$0.20	0.20	
Finish grading	1.0	sf/sf	$0.11	0.11	
		sf		$1.69	
Cap Unit Cost			say	$1.70	
Soil Cover Caps:					
Vegetation	1.0	sf/sf	$0.05	$0.05	
Topsoil	1.0	ft/sf	$0.44	0.44	
Compacted clayey soil	1.0	ft/sf	$0.30	0.30	
Finish grading	1.0	sf/sf	$0.11	0.11	
		sf		$0.90	
Soil Cover Cap Unit Cost			say	$0.90	
Dike, External, 12' high:					
Height	12.00	ft			
Crown Width	8.00	ft			
Outer Slope (run : rise)	3.00	ft/ft			
Inner Slope (run : rise)	3.00	ft/ft			
Total volume	19.60	cy/lf			
Volume of topsoil	1.70	cy/lf	$12.00	$20.40	1' thick
Volume of clayey soil	17.90	cy/lf	$4.50	80.55	
Vegetation	46.00	sf/lf	$0.05	2.30	
		lf		$103.25	
External 12' Dike Unit Cost			say	$103.00	
Dike, Internal, 12' high:					
Height	12.00	ft			
Crown Width	8.00	ft			
Outer Slope (run : rise)	2.00	ft/ft			
Inner Slope (run : rise)	2.00	ft/ft			
Total volume - clayey soil	14.20	cy/lf	$4.50	$63.90	
		lf		$63.90	
Internal 12' Dike Unit Cost			say	$64.00	

011217

DERIVED UNIT COSTS
SHERIDAN DISPOSAL SITE
Revised: 20 July 1988

Item	Quantity	Units	Unit Cost	Cost	Notes
Dike, Internal, 8' high:					Biotreatment basin
Height	8.00	ft			
Crown Width	12.00	ft			
Outer Slope (run : rise)	2.00	ft/ft			
Inner Slope (run : rise)	2.00	ft/ft			
Total volume - clayey soil	8.30	cy/lf	$4.50	$37.35	
		lf		$37.35	
Internal 8' Dike Unit Cost			say	$37.00	
Dike, Run-On Control, 3' high:					
Height	3.00	ft			
Crown Width	4.00	ft			
Outer Slope (run : rise)	2.00	ft/ft			
Inner Slope (run : rise)	2.00	ft/ft			
Total volume - clayey soil	1.10	cy/lf	$4.50	$4.95	
Side ditches	1.00	lf/lf	$0.12	0.12	
		lf		$5.07	
Run-On Control Dike Unit Cost			say	$5.10	
Potable Water Supply:					
Well, 4" diameter	400.00	ft	$40	$16,000	Drilling & materia
Submersible pump				500	
Geologist				1,000	
Subtotal (1 well)				$17,500	
Piping, etc				50,000	Allowance
Potable water supp , cost				$67,500	
			say	$68,000	

011218

DERIVED UNIT COSTS
SHERIDAN DISPOSAL SITE
Revised: 20 July 1988

Item	Quantity	Units	Unit Cost	Cost	Notes
Non-potable Water Supply:					
Well, 4" diameter	100.00	ft	$40	$4,000	Drilling & material
Submersible pump				500	
Geologist				1,000	
Subtotal				$5,500	
			X	4.00	
4 wells				$22,000	
Piping, etc				50,000	Allowance
Non-potable water supply cost				$72,000	
Haul Roads, 12' wide:					
Fill	2.00	cy/lf	$4.50	$9.00	
Grading	12.00	sf/lf	$0.06	0.72	
		lf		$9.72	
Haul Road Unit Cost			say	$9.70	
Maintenance Roads, 12' wide:					
Gravel	0.30	cy/lf	$18.00	$5.40	
Fill	2.00	cy/lf	$4.50	9.00	
Grading	12.00	sf/lf	$0.06	0.72	
Ditches	2.00	lf/lf	$0.12	0.24	
		lf		$15.36	
Maintenance Road Unit Cost			say	$15.40	
Off-site Transportation					
Loaded miles	85.00	mi/load	$3.00	$255	
Payload	20	ton/load		$12.75	
Incinerator ash	18.50	cy/load		$13.78	
Restoration of Disturbed Areas:					
Topsoil (6" layer)	810	cy/ac	$12.00	$9,720	
Grading	43,650	sf/ac	$0.06	2,619	
Seed and fertilize	43,650	sf/ac	$0.05	2,183	
Restoration Unit Cost		ac		$14,522	
			say	$14,500	

011219

DERIVED UNIT COSTS
SHERIDAN DISPOSAL SITE
Revised: 20 July 1988

Item	Quantity	Units	Unit Cost	Cost	Notes
Soil Mixing (6:1)					
Design waste quantity	34,000	cy			Sludge
Assumed working area	13.00	ac			
Spread fill soil (uncompacted)	204,000	cy	$4.00	$816,000	
Transfer waste to bulking area	34,000	cy	$3.00	102,000	Assumed pumpable
Number of lifts (6" thick)	23.00				Uncompacted 6" spread over working area
Tilling	900.00	ac-event	$63	56,700	3 tillings/lift
Compaction	238,000	cy	$0.50	119,000	
Total				$1,094,000	Rounded to thousands
Soil Mixing Unit Cost (6:1)		per cy raw waste		$32	Rounded to dollars
Volume of compacted, bulked soil	6.00	cy per cy waste			1.3 compaction factor
Soil Mixing (2:1)					
Design waste quantity	10,000	cy			Potentially affected pond soil
Assumed working area	13.00	ac			
Spread fill soil (uncompacted)	20,000	cy	$4.00	$80,000	
Transfer waste to bulking area	10,000	cy	$5.50	55,000	Excavate & haul
Number of lifts (6" thick)	3.00				Uncompacted 6" spread over working area
Tilling	120.00	ac-event	$63	7,560	3 tillings/lift
Compaction	30,000	cy	$0.50	15,000	
Total				$158,000	Rounded to thousands
Soil Mixing Unit Cost (2:1)		per cy raw waste		$15.80	
Volume of compacted, bulked soil	2.50	cy per cy waste			1.3 compaction factor

011220

DERIVED UNIT COSTS
SHERIDAN DISPOSAL SITE
Revised: 20 July 1988

Item	Quantity	Units	Unit Cost	Cost	Notes
Solvent Extraction Feed Preparation System:					
5000 gal. holding tanks w/ mixer	6.00	@	$14,000	$84,000	Vol. based on 1000 drums
Preparation area paving	5,000	sf	$4.60	23,000	
Curbing (6" high)	300	lf	$9.50	2,850	
Cutterhead dredge				66,000	Vendor ballpark quote
Liquid pumps	4.00	@	$5,000	20,000	Allowance, inc. 2 yr maint.
Solvent Extraction Feed Preparation System Cost				$196,000	Rounded to thousands

NOTES:
1. This table presents estimated unit costs to the General Contractor as of mid-1987, using Level D (basic) personnel protection.
2. Costs do not include General Contractor overhead & profit, contingency, engineering & construction surveillance, or quality control/quality assurance testing.

Item	Quantity	Units	Unit Cost	Cost	Notes
Incineration Feed Preparation System:					
5000 gal. holding tanks w/ mixer	6.00	@	$14,000	$84,000	Vol. based on 1000 drums
12,000 gal. blending tanks w/ mixer	3.00	@	$22,000	66,000	Mixer $8000, tank $1/gal.
Preparation area paving	40,000	sf	$4.60	184,000	150' square
Curbing (6" high)	1,000	lf	$9.50	9,500	perimeter + 2 solids work areas 20' square
Loader for solids handling				77,000	
Solids hopper-conveyor				33,000	Allowance per EPA cost figure
Cutterhead dredge				66,000	Vendor ballpark quote
Sludge pumps	3.00	@	$5,000	15,000	Allowance, inc. 2 yr maint.
Liquid pumps	4.00	@	$5,000	20,000	Allowance, inc. 2 yr maint.
Incineration Feed Preparation System Cost				$555,000	Rounded to thousands

NOTES:
1. This table presents estimated unit costs to the General Contractor as of mid-1987, using Level D (basic) personnel protection.
2. Costs do not include General Contractor overhead & profit, contingency, engineering & construction surveillance, or quality control/quality assurance testing.

DERIVED UNIT COSTS
SHERIDAN DISPOSAL SITE
Revised: 20 July 1988

Item	Quantity	Units	Unit Cost	Cost	Notes
RCRA Double Liner (sand):					
Sand layer (1 ft)	1	cf/sf	$0.52	$0.52	
Collection pipe	0.06	lf/sf	$2.75	$0.16	
HDPE liner	1	sf/sf	$0.75	$0.75	
Sand layer (1 ft)	1	cf/sf	$0.52	$0.52	
Collection pipe	0.06	lf/sf	$2.75	$0.16	
HDPE liner	1	sf/sf	$0.75	$0.75	
Clay liner (3 ft)	3	cf/sf	$0.30	$0.89	
Grade clay liner (rough, final)	1	sf/sf	$2.61	$2.61	
RCRA Double Liner (sand) Cost		sf		$6.36	
RCRA Double Liner (geofabric):					
Geofabric (Type I)	1	sf/sf	$0.40	$0.40	
Geogrid		sf/sf	$0.45	$0.00	
HDPE liner	1	sf/sf	$0.75	$0.75	
Geog[illegible]	[illegible]	[illegible]	[illegible]	$0.40	
HDPE liner	1	sf/sf	$0.45	$0.45	
Clay liner (3 ft)	3	cf/sf	$0.30	$0.89	
Grade clay liner (rough, final)	1	sf/sf	$2.61	$2.61	
RCRA Double Liner (geofabric) Cost		sf		$5.50	

BASIC UNIT COSTS
SHERIDAN DISPOSAL SITE
Revised: 6 May 1988

ITEM	Unit Cost	Units
OPERATIONS (Labor, Materials & Equipment):		
Excavation:		
Excavate & load clean soil	$2.50	cu.yd.
Excavate & load waste soil	$3.00	cu.yd.
Hauling (On-Site):		
Soil	$2.00	cu.yd.
Waste	$2.50	cu.yd.
Sludge (pumping)	$3.00	cu.yd.
Placement/Grading:		
Placement	$1.00	cu.yd.
Compaction	$0.50	cu.yd.
Rough grading	$2.50	cu.yd.
Final grading of clay liner	$0.11	sq.ft.
Finish grading	$0.06	sq.ft.
Waste Operations:		
Stabilization	$65.00	cu.yd.
Volume increase with stabilization	20%	
Fluid sludge volume increase	90%	
Land treatment:		
Tilling	$63	ac-event
Fertilizer & pH adjustment	$500	ac/yr
Sludge injection	$2.00	cy
Waste soil incorporation	$1.70	cy
Remove and handle drums:		
Intact - incineration alternatives	$110	drum
Intact - other alternatives	$500	drum
Ruptured drums - all alternatives	$15	drum
Off-site ash landfill disposal	$0.08	lb
Jetty System:		
Construction	$490,000	L.S.
Maintenance	$20,000	yr

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BASIC UNIT COSTS
SHERIDAN DISPOSAL SITE
Revised: 6 May 1986

ITEM	Unit Cost	Units
Others:		
Seed & fertilize - initial	$0.05	sq.ft.
Seed & fertilize - maintenance	$0.07	sq.ft.
Site maintenance	$75	ac-yr
Evaporation system operation	$10,000	yr
Slurry Wall	$5	sq.ft.
Trench excavation & backfill	$0.61	lin.ft.
Ditch construction	$0.12	lin.ft.
Cap maintenance	$125	ac-yr
Ground water monitoring, 12 wells	$36,200	event
Stormwater monitoring	$7,800	event
Plug existing monitor wells	$1,500	each
Water well installation	$40	ft

MATERIALS:

ITEM	Unit Cost	Units
Soils (in place):		
Clay, site source, recompacted	$8.00	cu.yd.
Sand, purchased (drainage layers)	$14.00	cu.yd.
Clean fill - dikes	$5.00	cu.yd.
Clean fill - other (compacted)	$4.50	cu.yd.
Clean fill - uncompacted	$4.00	cu.yd.
HDPE liner, 60 mil	$0.75	sq.ft.
Geofabric	$0.40	sq.ft.
Geogrid	$0.45	sq.ft.
Topsoil, purchased	$12.00	cu.yd.
Topsoil, on-site source	$4.50	cu.yd.
Pea gravel, purchased	$33.00	cu.yd.
Road gravel, purchased	$18.00	cu.yd.

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BASIC UNIT COSTS
SHERIDAN DISPOSAL SITE
Revised: 6 May 1988

ITEM	Unit Cost	Units
Piping & Connections:		
HDPE pipe, 2"	$2.50	lin.ft.
HDPE pipe, 3", perforated	$2.75	lin.ft.
HDPE pipe, 4"	$2.95	lin.ft.
HDPE pipe, 6"	$4.00	lin.ft.
HDPE pipe, 8"	$5.33	lin.ft.
PVC pipe, 4"	$6.43	lin.ft.
PVC pipe, 6"	$9.65	lin.ft.
PVC pipe, 8"	$12.87	lin.ft.
Concrete Drainage Inlets	$1,200	each
Concrete drain pipe, 18"	$15	lin.ft.
Other:		
Concrete slab, 6" thick	$4.30	sq.ft.
Concrete curbing, 8" high	$9.50	lin.ft.
Fencing	$7.40	lin.ft.
Pavement (roads & process areas)	$1.30	sq.ft.
Ground water monitoring well	$3,500	each
Lysimeter	$2,000	each
Leachate/runoff collection sumps	$1,000	each
NATURAL GAS	$3.80	M scf
POWER	$0.25	kwh
LABOR:		
(NOTE: Annual rates are for full-time project employees. Hourly rates are subcontractor rates. Both include fringe benefits.)		
Project Director	$80,000	annual
Supervisor/Foreman	$35.00	hr
Supervisor	$60,000	annual
Labor Foreman	$26.60	hr
Instrument Technician	$55,000	annual
Mechanic	$44,000	annual
Chemist	$35,000	annual
Technician	$30,000	annual
Operator	$30.35	hr
Operator	$36,000	annual
Assistant Operator	$30,000	annual
Laborer	$23.65	hr
Laborer	$25,000	annual
Health & Safety Officer	$45,000	annual
Site Security	$13.00	hr

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BASIC UNIT COSTS
SHERIDAN DISPOSAL SITE
Revised: 6 May 1988

ITEM	Unit Cost	Units
MULTIPLIERS FOR PROTECTIVE LEVELS:		
Level B	9.80	
Level B air & C suit (B/C)	5.75	
Level C	1.70	
Level D	1.00	
MACHINERY:		
Dump truck, 12 cy	$51,000	annual
Excavator, 1.5 cy	$100,000	annual
Front-end loader, 65 hp	$38,000	annual
Dozer, 200 hp	$120,000	annual
Water truck, 5000 gal. cap.	$25,000	annual
Backhoe, 2 cy	$650	day

NOTES:

1. This table presents estimated unit costs to the General Contractor as of mid-1987, using Level D (basic) personnel protection.
2. Costs do not include General Contractor overhead & profit, contingency, engineering & construction surveillance, or quality control/quality assurance testing.

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